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U. S. Naval Academy.

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A

Series of Ten Lectures

DELIVERED TO THE SECOND CLASS

OF

CADET MIDSHIPMEN

ON THE

Practice of Building, Launching, Docking and Fitting of U. S. Naval Vessels; together with a Short Explanation of the Method of Building Composite and Iron Vessels.

NAVY MUSEUM OF SALEM

BY

THEODORE D. WILSON,

Assistant Naval Constructor, U. S. N.

Naval Academy, October 4th, 1871.

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TO

Commander JOSEPH S. SKERRETT, U. S. Navy,

In charge of the Department of Seamanship, &c., U. S. Naval Academy,

THIS WORK

IS RESPECTFULLY DEDICATED,

By His Obliged and Obedient Servant,

THE AUTHOR.

PREFACE.

This work was prepared at the urgent request of many officers of the Naval Academy, for the use of the Cadet Midshipmen; it aims to embrace the practical part of the subjects, as applied to the art of Ship-Building at the present time in the United States Navy Yards.

In the ninth and tenth lectures, a brief description is given of the general method of building iron vessels in the principal private shipyards of England; most of these yards were visited and inspected by me officially in the summer of 1870. For many of the details connected with the building of iron vessels, the well-known work on Ship-Building in Iron and Steel, by E. J. Reed, C. B., Chief Constructor H. M. Navy, has been consulted.

The articles on *composite* ship-building are taken from the Transactions of the Institute of Naval Architects. I saw but *two* vessels building while abroad, on the composite principle, and those according to Jordan's System.

The article on magazines, shell rooms and position of bolts for pivot and broadside guns, is as laid down in the Ordnance Instructions for the U. S. Navy, with the exception of the sizes of materials used, which is from actual practice in the construction of them.

Stewart on Docks has also been consulted.

These lectures were hastily written, in order that the present second class of Cadet Midshipmen might have the benefit of them, and were intended only as an elementary treatment of the subject, to be used in connection with the "Model in Frame" of the U S. Steamer "Antietam," which was built under my supervision last year, at the Philadelphia Navy Yard, and is used as a practical illustration in the course of these lectures. The want of an elementary work on the subjects of these lectures, is evident to all acquainted with the wants of this institution; and should this, my first attempt at writing such a work, meet with success, I shall be pleased to revise it and add a chapter on "Laying Down" and "Taking Off" from the Mould Loft Floor; also one on "Masting" and "Sparring" of the U. S. Naval vessels.

THEODORE D. WILSON.

U. S. Naval Academy, 1872.

Errata in Tenth Lecture.

Page 91. Leave out "of" between "model" and "and."

" 94. On fourteenth line from bottom, for "forming," read "forms."

" 95. On fifteenth line from top, for "bend, "read "bent."

" 97. On sixth line from bottom, for "batteries," read battens."

" 99. On eighteenth line from bottom, for "checked," read "chocked."

" 100. On twenty-second line from bottom, leave out "and" between "fitted" and "fastened."

Wherever the words "stake" or "stakes" are found, they should read "strake" or "strakes."

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TENTH LECTURE.

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BUILDING SLIP.

A ship is usually built upon a piece of ground called a *slip*, which, in most cases, slopes gently toward the water. The slip should have a firm foundation, and, if possible, a floor of masonry, concrete or timber. Perfect solidity of the slip is essential to the strength and safety of the vessels built upon it. The building slips in all of the English dock-yards, and most all in our own navy yards, have granite foundations. Building slips are usually covered with what are called *ship houses*. This is essentially necessary where a wooden ship is to be left "*in frame*" to season for any considerable length of time. Exposure to the alternate action of sun and rain is very injurious, and will cause the vessel to decay in a very short time. Where vessels have been built outside of the ship-houses in our navy yards, and left to season for a time, temporary houses have been placed over them for their protection. Most of the English iron-clads are built in granite dry-docks. The advantage derived over that of building on slips, are as follows:

1st. No weights are required to be raised to elevated positions—an important item in building heavy vessels.

2nd. The workmen within and without the vessel are under the eye of the foreman; for, from the edge of the dock, he can, up to the time that the decks are laid, view all of them.

3rd. In building the vessel she lies on an even keel; all the work, therefore, can be fitted to correspond with plumb-lines.

4th. The most important point of all gained is, that the severe strains a vessel is subjected to in launching are avoided. The vessel being floated out of dock when completed.

BUILDING BLOCKS.

The blocks on which the keel of the ship is laid, are piles of short and thick pieces of timber, placed one above the other, to a height determined by the declivity of the slip upon which they are placed. The lowest piece of each tier is the largest, and is called the *bed block;* it extends out far enough on either side to admit of the bilge and bottom shores being stepped upon it. In a temporary building slip it is buried nearly its depth in the earth, and oftentimes piles are driven down in the slip and sawed off even with the surface—the bed blocks being placed on the heads of them—thus affording a permanent and safe foundation to build upon. The upper block of all is called the *cap block.* When the blocking is first set up, the cap block is put in of a parallel thickness; but previous to launching it has to be removed, for the purpose of clinching the keelson bolts over it, and when completed it is replaced by two wedge blocks, the latter being much easier to remove in launching. The blocks are set up from four (4) to six (6) feet apart. When the height of the blocks exceed six feet, recource is had to "*cribbing,*" which is the piling of long pieces of timbers in a fore-and-aft direction and athwartships, until the requisite height is obtained—cap blocks being placed on top of all This is a much safer way than that described in the text-book, (Meade's,) and the blocks under the "Antic-

tam's" model in the Seamanship Room are built up as described above.

Three rates of inclination have to be attended too in building a ship; that of her keel, that of the *sliding-way* on which she is to be launched, and that of the slip. The inclination of the keel varies for different vessels, in the model before you, it is $\frac{5}{8}$ of an inch to the foot, and the sliding-ways will be $\frac{7}{8}$ of an inch to the foot. The inclination of the sliding-ways is greater for light vessels than for heavy ones, ranging from $\frac{1}{2}$ inch to $1\frac{1}{2}$ inches to the foot, being made less for larger vessels to prevent them from acquiring an excessive speed when they are launched. The height of the after block is determined by constructing a sheer-plan of the ship as shown on the black-board in which H H represents a horizontal line, K F the lower side of the keel at the intended inclination and W W the intended inclination of the sliding-ways, the distance that the fore-foot of the vessel is below the line showing the inclination of the sliding-ways at that point, plus 9 inches, will be the height required for the after-block, in order that the fore-foot of the vessel will not touch at this point in launching. The remainder of the blocks will be regulated from the after-one of all.

No wooden vessels are built with their sterns raised up, and the highest blocks aft, as shown in "text book," Fig. 9, but several monitors have been built in that way, and one of the Colossos Class is now on the stocks at Charlestown Navy Yard, which sits nearly level on her blocking. The object of building in this way was, that in launching, the vessel would be water-borne at all points at the same time, and, the danger of straining, by having the after part water-borne before she was entirely clear of the ways would be prevented. I have seen a number of heavy armour-plated ships launched in the usual way and with perfect success.

KEEL.

Keels for all vessels in the Naval service are made either of white or live oak. The pieces are obtained in as long lengths as possible, varying in size according to the size of the ship. The siding-size of a keel may be obtained by multiplying the breadth of beam of the vessel by .42 (giving the size in inches and parts of an inch.) The several pieces forming the keel are joined together by plain horizontal scarphs, as shown in the sketch on the board. The scarphs are to be long enough to admit of the fastening of four frames through each. The nibs of the scarphs should come under a filling timber. Two rows of coaks are let into the lips of the scarphs, (as shown in the model.)

The keel when dressed up by the carpenters and the scarphs cut, is placed on the blocks, the lips of the scarph painted, a piece of felt cut over the coaks and the pieces forced together by means of clamp-screws. They are fastened by driving two copper bolts through each nib clinching them on composition plates, and not less than four copper bolts will be driven through each scarph under the filling and clinched on the under side of the keel. The size of the fastening varies according to the size of the vessel.

The keel is now regulated i. e., centered properly on the blocks and secured by cleats fastened to the cap blocks on either side of it.

A centre line is now marked on top of the keel, and from a batten called a "*room and space batten*," the position of the joint of each frame is transferred to the centre line of keel, squared across the top and down on each side of it; the number corresponding to the frame, being painted on either side of the keel, according to the marks on the batten. The stations of the frames on the batten were obtained from the mould-loft-floor where the vessel is *laid down* to her full size.

About three (3) inches above the lower side of the keel and about 5 feet apart or under every other joint of a frame a bolt is driven and clinched on alternate sides of the keel to prevent splitting from the large number of heavy bolts that will pass through it, and as a security from splitting when taking the ground.

RABBET OF KEEL.

A wooden keel has in each side a triangular groove or *rabbet* to receive the edge of the first ~~stake~~ of planking or *garboard strake*, it generally being formed to the figure of which *h g f* is a section, figure 11, Meade's. In the construction of many of our vessels, and in the one before you, the garboard strakes, two in number, on each side were secured to the keel previous to raising the frame; they could be worked much better at that time and they made a good support for the frame in raising it. The garboard strakes are secured by driving bolts edgewise through the first ~~stake~~ of plank and keel at intervals of five feet or under the joint of every other frame and clinching them on rings on alternate sides; the second strake fastens through the first and keel under the joint of the intermediate frame, the bolts being driven and clinched on alternate sides. The thickness of the garboard strakes is greatest amidships and next the keel but diminishes gradually so as to correspond with the thickness of the plank fore and aft and on the bottom.

FALSE KEEL.

The text book is in error in regard to the false keel being scarphed the same as the main keel. It is put on in length of 12 to 16 feet, having square butts, (no scarphs) and the butts placed so as to clear the lower nibs of the keel scarphs. The false keel is not put on until all the keelson bolts are driven and clinched, and before it is put on, is coppered with a double course of copper and spiked to the main keel with composition spikes, so that it could be forced off without much damage to the main keel.

STEM.

The *Stem* is the foremost boundary of the ship, being a continuation of the keel to the height of the vessel at the fore extreme of her; in vessels built for naval purposes, it is composed of *white* or *live oak* timber, and receives in a groove taken out of it, technically called a *rabbet*, the whole of the fore-ends of the outside planking called *fore-hoods* In large vessels the stem is, from the difficulty of finding timber of sufficient dimensions, composed of two or three pieces. The model before you "Antietam's" has her stem in two pieces, distinguished as being the *upper* and *lower* pieces of stem; these are united to each other and to the fore-end of the keel by *hooked scarphs*. These scarphs have *round* instead of *flat-coaks;* the *nibs* are fastened with two upper bolts in each, riveted on composition plates. The *scarphs* are fastened with four copper bolts in each, care being taken to keep them well clear of those of the apron and deadwood. The *stem* has at its lower end a siding equal to that of the keel, and is usually gradually enlarged upwards, until at the upper end it is about one-third part greater than at the lower end; the object of this is to give a broad bed for the bowsprit. The stem is reduced in thickness forward of the rabbet, technically called *bearding it*. The hooked scarphs joining the upper and lower stem pieces and the stem to the keel are further secured by having composition rings let in flush on each side of the stem over the scarphs and secured with copper bolts driven and clinched on alternate sides.

APRON.

The Apron is placed next aft of the stem to strengthen it and afford wood for the reception of the outside planking and the heels of the foremost timbers, it is either of white or live oak. The Apron may be justly considered as a portion of the fore deadwood being a continuation of it in a similar way that the stem is a prolongation of the keel; the size of it, in the siding or athwartship direction, is the same as that of the stem, and in large ships, where from necessity it is composed of two pieces; the pieces are made to shift scarphs with those of the stem; by *shift* is meant that it is placed intermediate between the scarphs of the keel and stem to ensure the greatest strength under the required combination of materials. The Apron is secured to the stem with round coaks and bolts about 20 inches asunder, care being taken to keep the fastening clear of the breast-hook bolts. The Stem and Apron are got out to the required shape and size from *moulds* furnished from the mould-loft and in accordance with the *building instructions;* when completed and secured together, they are raised to position by means of a derrick, regulated and then secured to the keel.—Shores or supports are placed forward and on either side of it, to keep it securely in place when regulated.

DEADWOOD.

The extremes of the ship, or the fore and after ends of her, having a form given to them that causes the *floor-timbers* gradually to become more rising or V like in appearance, which renders them first difficult to be obtained, and finally, not within the natural growth of timber, it then becomes necessary to have recourse to other methods to continue the assemblage of timber which compose the *frame* of a ship. The position in the length of the frame of the ship, where it would be advisable that the *floor-timbers* should be discontinued, must be determined by the practical builder with reference to the capabilities of his stock of timber; having fixed that point, called the position of the *last square frame*, the deadwood becomes the foundation, against which the *heels* of the remaining timbers or *cants* are abutted.

By reference to the model ("Antietam's") and plan, it will be seen that the *fore-deadwood* abuts against the *last square frame* and its forward end against the Apron, making a shift with the scarph which secures the stem to the keel. The Deadwood is worked the same width as the keel, and the keel tapering at the fore and after ends, the line of the upper edge of the rabbet necessarily rises up the Deadwood, to give the same breadth where the timber meets the Deadwood, thus forming what is termed the *bearding-line*. The Deadwood is composed either of white or live oak timber and is coaked to the keel, stem and to each other with round coaks.

STEMSON.

The *Stemson* is a curved piece of white or live oak timber placed in the angle formed by the apron and upper piece of deadwood as a further support to the stem, the lower end being scarphed to the forward piece of keelson, it is coaked to the deadwood and apron. The stem, apron, deadwood and stemson are secured together with through-bolts about 20 inches asunder, all the bolts below the copper line being of copper and above that of iron. The position of all these through-bolts are marked after the several pieces are got in place and bored through each piece separately so as to avoid bad holes. The necessity for this precaution is greater *aft*, where the fastening must be got in so as to be clear of the *shaft-hole*.

STERN-POST.

The *Stern-Post* forms the after-boundary of the frame of the ship, being the after-continuation of the keel to the height of the deck, and forming, similarly to the case of the stem and planking forward; the receptacle for the after-ends of the outside planking, a groove being taken out of it called a *rabbet* to receive these ends, which are technically termed *after-hoods*. The *Stern-Post* is made either of white or live oak, sided at the head and heel the same as the keel, but in a screw-steamer it is increased in size at the position of the shaft, as may be required. The *Stern-Post* is in one piece, having two tennons cut on the heel of it, and let into the keel and additionally secured by a composition dove tailed plate let in flush on each side and through bolted.

COUNTER TIMBERS.

In all round and eliptical sterns, timbers called *side-counter-timbers* are worked on each side of the stern-post to form the rake and contour of the stern, these timbers abut against the *last cant frame*, which heels on the deadwood; between these side-counter-timbersthere is a centre-counter-timber large enough to fill up the space between them; upon this centre-counter-timber, there is sufficient wood left in which a *rabbet* is cut for the bottom plank. These counter-timbers are securely bolted to the stern-post and to each other. The upper end of the *counter timbers* extend up to the height of the Gun-deck-port sills and the *rudder-post* is cut through it. The counter-timbers are worked out and secured to the stern-post and to each other before it is raised to position on the keel.

STERN-POST KNEE.

The *Stern-Post Knee* is placed in the angle formed by the keel and stern-post; it is bolted through the stern-post and keel with two copper bolts in each end before the deadwood is put on; it is also coaked to the keel and stern-post.

INNER-POST.

The *inner Stern-Post* is worked on the inside of the main post running down to the throat of the stern-post knee and is coaked and temporarily fastened to them. It is made either of white or live oak and of the same siding size as the main post.

AFTER-DEADWOOD.

The position of the *last square frame* having been determined, the *After-Deadwood* may be got out and put in place, being run up to the height of the floor timbers, and when the frames are raised the after-piece of keelson will run aft on top of the deadwood, the several pieces being coaked together and fastened as shown in the plan on the black-board. On top of the deadwood comes the shaft box, which is generally built and secured together as shown on the black-board. In the angle formed by the inner-post and *shaft box*, a large knee or piece of curved timber is placed, called the *After-Deadwood knee*, it is coaked to the post and shaft box.—The fastening is marked off and bored through each piece separately as before described.

LECTURE SECOND.

AFTER STERN POST OR RUDDER POST.

In all screw steamers having *propeller wells*, a second or *after stern post* is required; in vessels of the "Wabash," "Juniata" & "Iroquois" class, it is made of white or live oak, tenoned and secured to the keel with composition *dove tailed* plates, let in flush, and through bolted with copper bolts, countersunk and riveted flush. The heels of these two stern-posts are further secured to the keel and to each other by *composition-castings* extending along the keel and running up to the castings for the *propeller shaft* on each post, they are in *two halves* and are secured with copper bolts driven from alternate sides and flush riveted. The *rudder* is hung to this after post.

In vessels of the "Plymouth" & "Omaha" class, the *after*-stern-post is made of *copper*, and connected with the forward post by a *composition casting* extending to the *propeller bearing* on the *main-stern-post*, and on each side of the after-end of the *keel;* under the middle of the propeller opening it is about 4 inches in thickness. The width of this *metal-post* is 2 feet: in thickness on the fore part, that of the two plates of copper of which it is made: and on the aft side in thickness, 7 inches. The *head* of the *metal stern-post* is secured to a *composition plate* fastened to the *counter* and the *keel* secured to the *composition casting* or *shoe*, and so fitted that the *post* can be removed when it becomes necessary to remove the *propeller*. The *rudder* is made of *composition* and hung in the usual way.

STERN FRAMING REQUIRED FOR A LIFTING-SCREW.

The *disconnected lifting-screw* used in the "Franklin," "Wabash," "Hartford," "Juniata," "Wyoming," "Iroquois" and vessels of their class, is detached altogether from the *propeller-shaft*, and works on a short axis of its own, in a frame of its own, and a couple of beadings of its own; all of which are let down and taken up by means of two grooves cut in the *forward* and *after stern-posts*, and they are merely dropped into a *seat*, which forms a continuous line with the *propeller shaft*. The revolution of the screw is simply accomplished by a *feather* on the *end* of the *propeller* dropping into a *slot* in the *end* of the *propeller-shaft*; so that, like a screw driver and a screw they must revolve together. This will be found to be well illustrated in the model of the *stern* of the "Franklin," now before you.

To illustrate the manner of *framing* a *stern* where a *lifting-screw* is required, I shall call your attention to the *model* of the *stern-frame* of the "Iroquois." In this case, the *side-counter-timbers* are spread apart far enough to form the side of the *propeller-well*, *heeling* against the *after-cant*, the after part of the well being formed by a short timber called a *transom* secured to the *after-stern-post*:

between the *side-counter-timbers* are several short timbers, heeling on the *transom*, these are called *centre-counter-timbers* and are numbered 1. 2. 3., &c.

The "Tennessee," "Albany," "Florida," "Delaware," "Antietam" and vessels of their class have no *after-stern-post* or *rudder-post*, an *equipoise-rudder* being used, the construction and fittings of which will be taken up and described in its appropriate place.

The *wooden twin-screw* monitors "Terror," "Amphitrite," "Colossus," "Thunderer" and vessels of their class have only one *stern-post*, the *rudder* being hung to it.

STERN FRAME OF SQUARE STERNED SHIPS.

The *stern frame* of *squared sterned* ships is an assemblage of oak timbers united together, forming the after part of the ship. It is composed of the *stern-post*, *inner-post*, *transoms* and *fashion* pieces.—They are all secured together before the frame is raised and secured to the keel. The *stern-post* is united to the *keel* as before described. At the fore side of the *stern-post* an oak timber equal in siding size to the *stern-post* is placed, called the *inner-post*, for letting the *transoms* into. The upper end of this timber formerly abutted under the *deck* or *wing transom*, but it is now continued up to the head of the *stern-post*, and its lower end *tenons* into the *keel* with *one tenon* of the same dimensions as those of the *stern-post*.

TRANSOMS.

The *transoms* in *square-sterned* ships are transverse timbers, connected and placed square with the *stern-post*. The upper one is called the *wing-transom* which forms the basis of the upper *stern*.—The *after-sides* of all the *transoms* below the *wing-transom*, and the *wing-transom* to a short distance below the upper edge, partake of the form of the body, and receive the fastening of the exterior planking. A short parallel distance below the upper edge of the after side is called the *margin*, at the lower part of which the planking ends. A rail called the *tuck-rail*, is fixed on the margin, forming an abutment and finish to the ends of the plank. The next principal transom below is called the *deck-transom*; it corresponds in height, and supports the after extremity of the lower deck, and has its upper surface of the same round up: this transom is always left as wide as possible for fastening the ends of the deck. Between these two transoms, which are governed as to their situation, one or more transoms are placed according to the distance between them, called *filling-transoms;* the remaining *transoms* are distinguished by numbers, according to their order below the *deck transom*. The whole of the *transoms* are of *oak;* and are scored, and faced upon the *stern* and *inner post*, to which they are bolted, with one bolt passing through each, driven from the fore side of the *transom* and clenched upon the after part of the *post*.

THE FASHION PIECES.

The *fashion-pieces* are timbers having their outer surfaces corresponding to the form of the body, which face over the ends of the

transoms, and are secured to them by one bolt in the end of each. The sides of the *fashion-pieces* are in a vertical plane but oblique to the plane of elevation. The *fashion-pieces* are from one to three in number on each side. The foremost one extending above the *wing-transom*, a sufficient height to form a scarph for the top timber, and to bolt the heels of the *side-counter-timber;* the second one forms an abutment under the *deck-transom;* and if three, the after one abuts under the third transom below the deck. The whole of them have their lower ends resting upon a stepping formed in the deadwood, to which they are bolted with one bolt that passes through each *fashion-piece* and its *opposite*. A model of the framing of a *square-sterned* vessel can be seen in the Seamanship Room composed of the several parts before described.

Owing to the difficulty of providing timber suited for transoms, the whole of them, except the *wing-transom*, were substituted by timber similar to the *fashion-pieces*, which formed an abutment under the *wing-transom*, and were continued to the *stern-post*.

Ships built on the present plan, with *eliptical sterns*, have the common *cant-frames* continued round to the *stern-post*, and up to the *top-sides;* thus avoiding, entirely, the necessity of transoms.

FRAME.

The frame of a ship is composed of timbers placed vertically, which give the form of the ship. These timbers are secured together in *independent assemblages* called *frames*. It is divided into the square *frame* which is placed transversely, and the *cant frame*, which is placed obliquely to the longitudinal vertical plane. The timbers of the *frame* are distinguished by the names: *floor*, *first*, *second*, *third*, *fourth*, *fifth* and *sixth futtocks*, and *long* and *short top-timbers*.—These are all the timbers that constitute one frame.

FLOORS.

The floors lay directly across the keel and have a long and a short arm on either side, and, together with the keel are those timbers which will have to sustain the body when it takes the ground, and becomes inclined; they should, therefore extend in the fullest part of the body, beyond the point which would come in contact with the supporting surface. These timbers extend, in general, as far as the square body extends, or as the acuteness of the body will admit of timbers being obtained of the proper shape to form them. The floors of ships commonly extend out from the keel to *one-fourth* the breadth on each side, and at this place the rise of the floor is usually determined. When they are nearly horizontal from the rabbet of the keel, the ship is said to have a *flat floor;* and when the flatness extends for a considerable distance longitudinally, she is said to have a *long floor;* and as the floors rise above a horizontal line from the rabbet, the ship is said to have a *rising or sharp* floor. In the model of the "Antietam," the floors are scored down over the *keel* and two *garboard strakes*, the latter having been secured to the keel when it was laid. The depth of these *scores* are determined in laying off, and are cut out of the floor-mould.

The distance from the upper edge of the rabbet of the keel to the upper part of the floors, at the centre line, is called the *cutting down* or *throating;* and the line bounding the upper part of the floors, and upper part of the deadwood before and abaft the floors, is called the *cutting down* or *throating line.*

The practice of placing two sets of floors across the keel having a *long* and a *short arm* on alternate sides is of recent origin, and is consequent upon the great difficulty in obtaining *first futtocks* of sufficient length, size and crook for ships of the largest classes. It is regarded as a great improvement, inasmuch as it rids the keel of the range of butts with which it was covered under the old system, which was to have the floor timber extend an equal distance out from the keel on each side of the centre line and the heels of the *first futtocks* to butt over the centre line of the keel

The futtocks are a continuation of the floor timbers in the frame and the upper timbers are the *tops* and *half top.*

The frames of vessels are composed of *Live Oak*, *White Oak*, *Locust*, *Hackmatack* and *Red Ceader.*

White and Live Oak is used for the floors and futtocks; Locust and Red Ceader for the tops and half-tops. "Hacmatack" is sometimes used for the upper futtock towards the ends of the vessel.

The *timbers* of the frame are so disposed, that they give *shift* to each other; the upper and lower ends of the timbers, which are called the *heads* and *heels*, coming near the middle of the adjoining timbers of the frame. The *first futtock* abuts against the short floor head; the heel of the second abuts against the head of the long floor; the heel of the third abuts against the head of the first; the heel of the fourth abuts against the head of the second; the heel of the fifth against the head of the third; the heel of the top-timber abuts against the head of the fourth, and the heel of the half-top abuts against the head of the fifth. The *futtock* should not be less than 10½ feet long in vessels of the "Antietam" class. The timbers of the frame are close together, and each *lap* or scarph is bolted with 3 iron bolts. These bolts are 3 inches less in length than the *siding* size of the frame and are punched in 1½ inches, taking care to keep them clear of the *lodge knee* and *waterway* bolts. The heads and heels of all the timbers are *coaked* together with round *coaks*, and there will be a *three* inch *coak* between the timbers at each frame bolt; the bolt passing through the *timbers* and *coak*. These *coaks* are made of seasoned Oak, Locust or Lignumvitæ.

The frames are distinguished in two ways, viz: by letters and figures or figures alone; when both are used, those before the *greatest transverse section* are denoted by letters, and those *abaft* by figures; beginning from this section, which is called *dead-flat*, and distinguished thus⊕: but should there be several sections of the same area, which is frequently the case, those before are called A. and B, &c., flats, and those abaft, 1. and 2. &c., flats, and are marked thus: (1,) (2,) (A) (B.)

METHOD OF FRAMING.

While the work of preparing the *keel*, *stem*, and *stern-frame* has

been going on, workmen have also been busy getting the *frame-timber* out, according to the moulds and directions furnished from the *mould-loft*. Presuming that this is well underway, preparations are made for putting the frames together and raising them. For this purpose a *platform* is built the entire length of the *keel* somewhat higher than the lower side of it, and wide enough to put the *dead-flat* frame together on. The *floor-timbers* are placed across the *keel* opposite their several stations, (which in the "Antietam's" model are denoted entirely by numbers,) and the remaining timbers of the frame on either side of the platform. Blocks are now laid on the platform level with the top of the keel; the *lower course* of timbers placed on them according to the *moulds*, and the heads and heels *coaked together*; the *upper course* is then put in place, the position of the *coaks* in the heads and heels and scarph or *lap* of the timbers are marked; the upper course is then taken off, the holes for the coaks are bored, placed in the lower course and the upper one is driven down upon it. The *frame bolts*, three to each scarph, are then driven and punched in 1½ inches. Pieces of white or yellow pine plank called cross-spawls are now put on the frames at the proper height for putting on the *clamps* of the upper and lower deck, and of sufficient strength to build a stage to work on.

These cross-spawls are cut to the proper breadths of the frames at the heights they are put on, as taken from the floor of the *mould-loft;* the frame is then ready for raising, which is done with two pair of *shears*, one pair on each side, standing fore and aft and properly guyed. The frames when up are placed in their true position, that is, the *joint* of the *frame* to the *station* marked on the *keel;* making the plane of their sides *athwartships* and perpendicular to the *keel*, and the centre of the *cross-spawl*, which is always marked upon it, vertical to the centre line of the keel; a *plumb bob* is hung to the centre of the *cross spawl* before raising the frame to centre it by; the frame is then secured by placing *shores* under them until the *ribbands* and *harpins* are worked.

The operation of *framing* is commenced at dead flat and carried on both forwards and aft, at the same time.

Third Lecture.

REGULATING THE FRAME.

When the frames are first raised, they are secured in a temporary manner by placing *shores* under them and small pieces of plank called *stay lathes* are nailed from the head of one frame to another. The frames are secured in their position, until the outside planking is brought on, by pieces of *oak* or *yellow pine* plank from *five to seven* inches square, extending the length of the square body called *ribbands*, and at the extremities or where it crosses the *cant bodies*, by pieces formed to the curve of the body called *harpins;* and at the *sirmarks* where the ribbands and harpins cross the frames they are attached to them with screw bolts called *ribband screws*, the upper end of the ribband screw having an eye worked in it, to admit of turning it in with a lever. The *sirmarks* spoken of above are transferred from the *frame moulds* to the *timbers* of the frame, they mark the point at which the *bevellings* are to be applied, also the *head* and *heel* of each timber of the frame; the lines laid down on the mould-loft floor called *diagonal lines* mark the *head* and *heels* of the timbers and it is to these stations called *sirmarks* that the ribbands and harpins are put on. On these ribbands and harpins the joint of each frame must be marked, the position of each joint being first transferred from the mould-loft floor to a batten called a *room* and *space batten*, from which it is transferred to the ribbands. Moulds are made in the mould-loft and *levels* taken for the purpose of getting out the *harpins* to the proper shape, and the position of the joint of each *cant-frame* is marked on it and transferred to the harpin, also the position of the *hawse pieces* The *floor ribband* is the first one put on, as soon as several frames have been raised it is put on and shored up to regulate the floor surface, and of sufficient strength to bear the weight of the entire frame when raised.

Staging is erected around the vessel and the ribbands are put on as soon as a sufficient number of frames have been raised; as soon as the entire *square body* is raised the *harpins* are secured at their proper stations, the forward ends of those in the fore body being secured to the *stem*, and the after ends of those in the after body to the stern frame, the other ends generally lapping over three or four frames in the square body.

A ship may be said to be regulated when the stem and stern-post are found to be plumb, and a line extending from the *centre* of one to the *centre* of the other, and at the same time cutting a *plumb-line* over the centre line of the *floors*, from the centre of each *cross-spawl*. When thus bound in ribbands, and securely shored with *three tier* of shores set up properly and their heels secured to prevent them from shifting, the ship may be said to be fairly regulated.

The *knight heads*, *cants* and *hawse pieces*, have been worked out are now to be raised and regulated, *butts chocked* and fillings put in.

KNIGHT HEADS.

The *knight heads* are timbers placed on each side of the apron when the rabbet is on the after edge of the stem and partly on the apron.—

These timbers give support to the bowsprit, and render more secure the foremost extremities of the exterior planking, called the hooding ends; they extend a sufficient height above the bowsprit to receive a cheek over it, and sometimes above the chock to form a timber head, and at other times to receive the planking for the forecastle. When the diameter of the bowsprit exceeds the siding of the stem at the head too much, so that the knight-heads would be cut considerably to allow the bowsprit to pass between them, which will take place in small vessels and all upwards having a full bow, a piece is then introduced between the apron and stem, and knight heads called a *stem piece*, to give them more spread.

The *knight heads* and *stem pieces* are of oak or locust, and are made conformably to the sculling of the frame, in and out, except the upper ends where there is an additional substance called the *bolster*, equal to the thickness of the outside and inside planking, in the make of the bowsprit, extending from about one foot above to one foot below; this wood is left to prevent joints in the hole for the bowsprit

The knight heads and stem pieces are bolted to the stem; when the body is not too *acute*, the bolts pass through both the bolts are driven from each side through one knight head and stem or apron only.

In addition to the bolts, the knight heads are *coaked* to the stem or apron.

CANTS.

A ship is generally spoken of as divided into *fore* and *after* bodies, and these combined constitute the whole of the ship. They are supposed to be separated by an imaginary athwartships plane at the middle part of the ship, called the midship section or *dead-flat*.

The midship body is a term applied to an indefinite length of the middle part of the ship longitudinally including a portion of the fore body and of the after body. It is not necessarily parallel or of the same form in its whole length.

Those portions of the ship which are termed square and *cant* bodies may be considered as sub-divisions of the fore and aft bodies. There is a square *fore body* and a square *after body* towards the middle of the ship, and a *cant fore body* and a *cant after body* at the two ends. In the square body the frames stand at right angles to the centre line of the keel, and are athwartship vertical planes. In the *cant* bodies the joints of the cants are still vertical, but have gradually to be *canted* or swung around to an angle of 90° or a quarter of a circle to meet the stem, the plane of whose sides is fore and aft; the heels of them also have a less space for their reception, which causes the practical builder to reduce the cant timbers in their siding or thickness at the heels, to make them close joints, or, indeed, angle against each other, from a given point taking the wood away partly from each. The cants are put forward in the fore body and aft in the after body. The reasons for the frames in a wooden ship being canted is, that in these parts of the ship the timbers would be too much cut away on account of the fineness of the angle formed between an athwartship plane and the outline or water-lines of the ship. The timber is therefore turned partially around till the outside face coincides nearly with the desired outline. And it is by this movement that the side of a frame in the cant fore body is made to point forward and in the cant after body to point aft.

The timbers of the cant-frames are close together coaked and bolted the same as the square frames The heels of the cant-frames are *boxed* into the deadwood about $1\frac{1}{2}$ inches for a length of from 18 to 24 inches but are not cut into the after deadwood in the range of the shaft hole; the heel of each timber of the cant-frames is bolted through the deadwood with two copper bolts and riveted on rings on alternate sides.—When the cants are framed, tenons cut on the heel and mortise in the deadwood they are raised, regulated by the stations on the harpins, and heels secured to the deadwood. The cant-frames are designated as Cant Nos. 1, 2, 3, &c., Fore body. Cant Nos. 1, 2, 3, &c., After body.

HAWSE PIECES.

The hawse pieces are the cant frames to the number of six or seven next aft of the knight heads, they either heel against the fore side of the foremost cant timber, as shown in the *plan of the "Brooklyn,"* or run down and take the common stepping with the cants, as shown in the model of the "Antietam"

The hawse pieces are bolted to the apron and to each other with iron bolts. The bolts should be kept clear of the breast hooks and hawse holes.

CHOCKS.

In addition to the coaks which are placed in the butts of the frame timbers, a seasoned locust or white oak *chock* is placed between the frames opposite to each butt, they can be seen in the 'Antie'am's' model where they are six inches in thickness, *dove-tailed* one half an inch into the timbers they abut, the grain of the wood is fore and aft, and they are driven in tightly over all the butts above the fillings, taking care to keep them about one inch clear of the outside of the frame to prevent the water from lodging on them, trimming them off fair with the inside of the frame.

FILLINGS.

In all wooden vessels built for naval purposes the spaces between the frames are filled up with filling timbers level athwartships to the height of one foot above the level of the *floor* timbers, the heads of the fillings rising gradually forward and aft to make a fair line, as shown in model of "Antietam." These fillings are composed of either white oak, live oak or hackmatack; white oak in a white oak frame, live oak in a live oak frame amidships, hackmatack or pine forward and aft, and in some vessels pine has been used In getting out the floor timbers of a frame, they are obtained large enough in siding size to fill up the entire room and space, if possible, amidships, thus obviating the necessity of putting fillings in, but where this cannot be done fillings are put in. Where the fillings cross the keel they are bolted to it and they are secured to the frame by driving tree-nails cornerwise into it. The joints of the frames and fillings are caulked inside and outside, so that that part of the vessel would be watertight even supposing the bottom plank to be torn off by some accident.

Fillings are placed between the cants and hawse pieces; in the wake of the fore, main and mizen rigging; wherever an air port is located, where the breeching stirrs or gun tackle bolts comes be-

tween the frames and wherever a valve connected with the magazines, pumps, boilers or engines comes through the bottom or side of the vessel, or where a hanging knee comes off a frame.

The advantages obtained by filling in the spaces between the floor timbers are these:

To add to the strength and durability of the fabric; to preserve the health of the crew from the effects of the impure air arising from the filth which soon collects in these openings; to render the ship less liable to leakage as well as to facilitate the stoppage of any leak; and lastly, to increase the thickness of the bottom, thereby lessening very considerably the danger to be apprehended from getting on shore or founding at sea. That it tends also to the durability of the ship will be inferred from the following positions:

1st. That the openings in the old principle are, after the ship has had any considerable length of service, choked up in many places with an accumulation of filth.

2d. That no free circulation can be obtained in these openings by any means.

3d. That timber being either freely exposed to, or excluded from the air, is equally preserved.

4th. That it has been found, on examining the frame and plank of old ships, that those parts (now filled in) generally decay sooner than the rest, viz: from the floor-heads in the midships, and from the deadwood forward and abaft to the height of the orlop clamps.

The butts of the frames having been chocked, and the fillings all in the several operations of putting in the *keelsons*, *breast-hooks*, *riders* and *diagonal-braces* may be proceeded with.

KEELSONS.

Keelsons are distinguished as *main keelsons*, *sister keelsons*, *bilge* or *boiler* and *engine keelsons*.

MAIN KEELSON.

The *main keelson* is a timber in the interior of the ship, placed immediately over the keel, lying upon the upper part of the floors as far as they extend, and before and abaft them upon the deadwood. It is for uniting in one mass, the keel, deadwood and *floors*, that a compact union may be formed throughout the system. The keelsons are of white or live oak timber, the main keelson is generally put in, in two depths, the scarphs connecting the keelson pieces are cut, coaked and fastened, the same as those of the keel, care being taken to have the scarphs properly shifted, and clear of each other, and of the keel scarphs.

The lower piece of the main keelson is coaked to the floors, and fillings with round coaks three inches in diameter; the upper and lower pieces are coaked to each other with square coaks in two

rows; there will be driven through the keelsons and each floor timber, two copper bolts, where the first futtocks do not abut on the keel; but where a long and a short arm floor is used, then both timbers of the frame have two similar bolts in each; these bolts should be driven on the alternate edges, and are riveted on composition rings on the lower side of the main keel. Where cant-frames are, and the keelson forms part of the deadwood, the deadwood bolts take the place of the bolts above named.

SISTER KEELSONS.

The *sister keelsons* are on each side, and close adjacent to the main keelsons, extending forward and aft, until the outer edge becomes six inches in depth, the top being parallel with the top of the main keelson, and from six to nine inches below it. These keelsons are coaked to the fillings and floors, as the main keelson; the scarphs are properly shifted a little less in length than those of the main keelson; coaked and fastened as other scarphs. Through these keelsons, in every timber, there will be one copper bolt riveted on the outside of the garboard strake. Where it can be done, these keelsons are bolted athwartships through the lower peice of main keelsons, about five feet asunder, driven and riveted on alternate sides.

ENGINE AND BOILER, OR BILGE KEELSONS.

In all steamers there are two *engine* and *boiler*, or *bilge keelsons* on each side, parallel to the sister keelsons, and extending forward and aft until they become on the outer edge six inches in thickness, when they will terminate. They are in height and distance asunder to correspond with the plans furnished by the Bureau of Steam Engineering.

FOURTH LECTURE.

SUBJECT.—*Capping on Main Keelson; Water-Courses; Diagonal Braces; Breast, Stem and Deck-Hooks; Port-Sills; Deck-Clamps; Bilge Strakes, Thick Strakes and Ceiling.*

CAPPING ON MAIN KEELSON.

A *capping* of oak plank, from two to four inches in thickness, is put on top of the main keelson, after all the keelson-bolts have been driven; it is secured either with spikes or bolts. The *heels* of the berth-deck *stanchions* tenon into this capping.

WATER-COURSES.

The *water-courses*, under the keelsons, are cut in the fillings between the floor-timbers.

DIAGONAL BRACES.

Sir Robert Steppings, by whom the system known as *filling in* was introduced into the practice of ship-building; also introduced, as a substitute for a portion of the internal planking, a combination of wood-trussing to strengthen the ship, illustrating the intended effect by a reference to the stability given to a five-barred gate by the bar which is placed across the horizontal portion of it. The illustration would have held good had the strain been similar to that which his trussed frame in the hold of the ship was subjected. In the gate, the stiffness being required in the vertical position, the cross-bar is effective; but the same gate would be found weak if its strength was tested by a force applied to bend it horizontally. This trussing-frame, called, by its projector, a *diagonal frame*, was composed of timbers nearly equal in dimensions to the lower timbers of the ship, disposed diagonally or athwart the frame of the ship; but in the lower part, or near the keelson, this trussing, in flat-floored vessels, was wholly out of comparison with the vertical position of the bar of the gate; and in those ships having a rising-floor it only approximated to it. The diagonal framing thus becomes nearly useless as a truss, and its only beneficial effects were to unite the several timbers of the frame together in a horizontal direction. This framing was also found to be subject to early decay, the more especially so where old ship-timber was used for this purpose, as originally suggested by the projector; and, moreover, to yield little strength to the ship.

Modern times have introduced a system of iron diagonal trussing, possessing considerable advantages over all others yet introduced.

The *iron diagonal braces* vary in thickness from $\frac{5}{8}$ to $\frac{3}{4}$ of an inch, and from 3 to $4\frac{1}{2}$ inches in width, according to the dimensions of the vessel. They are placed on the inside of the frame timbers, so that the timbers of the frame can be more readily removed when

repairs are required to be made. There are two sets placed at right angles to each other, one of which will let into the timber, and be laid at an angle of 45° with the joint of the frames; the upper ends being under the strap which is at the lower side of the plank sheer, and the lower ends will be below the turn of the bilge, having a bolt in the first futtock and long floor-timbers; the other tier will lay on the timbers, the clamps, ceiling, &c., jogging over them. The upper end of the braces will be between every other frame or five feet asunder, and they will be riveted to an iron strap running entirely around the ship on the inside at the lower side of the plank sheer, called a head-strap. The head-strap has a bolt in every timber. The braces are bolted to every timber that they cross, and hot riveted to each other at every crossing between the frames; above the copper fastening the bolts in the timber go through the outside and inside planking and iron braces, being riveted on rings on the inside planking, thus one bolt secures all three; below the copper fastening one iron bolt is driven in each timber that the brace crosses, being driven from the inside and riveted on rings on the outside of the timbers before the planking is put on; the tier of braces that let into the timbers act as struts, and reach downwards from the ends of the vessel towards amidship below, running past each other, alternating amidships.

The tier that lies on the timbers act as ties and reach downwards from amidships, towards the ends of the vessel. Great care is requisite in letting these braces closely into the timbers, and in jogging the plank over them.

[Note.—In diagonally bracing many of our naval vessels, the old-established system of letting the struts and ties alternate amidships has not been followed out; the general practice now, is to let one tier of braces into the frame at an angle of 45° with the joint of the frame, and the other tier to lie on the timbers; the head-strap is let in flush, the head of the struts being under and the ties over it. By reference to the models of the "Omaha" and "Congress," in Seamanship Room, this system of diagonal bracing can be seen.]

By reference to the models above named, it will be seen that the overhang of the stern is supported by iron straps; one of these is generally placed at or near the poop-deck, one at or near the rail, one at or near the port-sill, and the other near the rudder-port. In the "Antietam" the upper straps should run about twenty-four feet forward of the aft-side of main stern-post; the lower straps reach upwards towards amidships until they reach the upper straps, to which they will be hot riveted; the lower one should reach as far forward as the quarter-port will admit; each of these straps is welded in one piece, and fastened, to every timber crossed by it, with one iron bolt riveted on the inside of the timbers, if below the copper line, or on the inside of the planking when above.

In order to connect the deadwood below the shaft with the frame timbers that are above it, three straps or diagonal braces of composition are placed on each side of the vessel, laying on the deadwood

and timbers, and the plank jogging over them; secured with copper bolts driven and riveted on the straps on alternate sides, where it can be done.

DIAGONAL BRACING ON OUTSIDE OF VESSELS.

In addition to the diagonal bracing on the inside of the frames, vessels of the "Congress" and "Severn" class have *diagonal braces on the outside*, running from the plank sheer to the turn of the bilge for a length of 150 feet amidships; one tier of these straps lets into the timbers, the other tier lies on the timbers, the wales jogging over them; they are riveted together at the crossing between the frames, and all the bolts from the diagonal bracing on the inside rivet on them. The braces are so placed that the bolts securing them to the timbers shall pass through the iron braces on the inside.

BREAST-HOOKS, STERN-HOOKS AND DECK-HOOKS.

To unite the two sides of a ship together at the fore and after ends, or at the head and stern of a ship, in the cant bodies, where the floors do not cross the keel, inside timbers are worked.

Forward, these are called *breast-hooks;* aft, they are called *stern-hooks*. These hooks have equal arms extending across the centre-line of the ship, at which place, or at their throating, they are the widest, or of the most moulding. The lengths given to the arms of these hooks are determined by the store of timber, and the number of them is at the discretion of the practical builder; they are equally spaced between the *deck-hooks*, which latter may very well be included under the same head with them, with this distinction, that while *breast-hooks* are placed square to the stem and form of the bows, by which position they cross several timbers of the frame and tie them together, the *deck-hooks* must have their upper surfaces to lie with the round up of the beams, and to the sheer of the decks, and that their positions are fixed, from being at the height of the several decks.

In vessels of the "Wabash" class, there is a *hook* over the bowsprit, one to each deck, one to each between-decks, and three or four in the hold below the berth-deck forward.

In vessels of the "Antietam" class, forward, there is one hook to each deck, one to each between-decks, and two in the hold below the berth-deck. Aft, there is one at each deck, two between the gun and berth-decks, and two in the hold below the berth-deck.

In the "Wabash" class, the *hooks* are composed of large pieces of live-oak timber, cut for that purpose, and which can generally be obtained, for full-bowed vessels, of the proper shape in one piece; in sharp-bowed vessels these hooks are made to the desired shape by placing a piece of timber, called a pointer, on either side abuting against the apron, with a triangular piece, called a chock, in the angle made by the two pointers, and an iron hook on the inside of the

pointers and chock let in flush; a lodge and a lap-knee is sometimes used instead of the iron hook.

These hooks are fayed against the timbers, and secured with one bolt in the throat and two in every timber that they cross. The throat-bolt is driven from the inside and riveted on a ring on the front of the stem, the others are driven from the outside after the plank is put on, and riveted on the face of the hook. If iron hooks are used in the hold, then they must be fastened with iron bolts driven from the face of the hook, and riveted on rings on the outside of the frame, before the outside plank is put on.

It may be fairly assumed, that the various operations of working out, and putting in the *port-sills, deck-clamps, bilge-strakes, thick strakes, ceiling, planking outside, getting out deck-frames,* &c., is now fairly underway, and I will describe each part in its turn:

PORT-SILLS.

The *port-sills* are pieces of white or live oak, forming the upper and lower part of the ports; they vary in siding size from six to nine inches, they are set with the round of the beam, and dovetailed to the frame timbers that they cross and abut.

The size of the ports is determined by the calibre of the gun that is to be used in them, and the height of the lower part of the port, or upper side of the lower *port-sill* from the deck, is determined by the Bureau of Ordnance.

DECK-CLAMPS.

The *clamps* are ranges of thick oak or yellow pine plank, extending the whole length on the inside of the frame, and intended to support the ends of the beams of the different decks; they are in two or more strakes, according to the deck they are connected with.

[NOTE.—The heights of the several decks are transferred from the mould-loft floor to the frame moulds, and the corresponding sirmarks are cut in on the frame timbers, it is to these sirmarks that the sheer battens for the several decks are placed, and after being properly regulated, the sheer of the deck is marked across the inside of each frame.]

In vessels of the "Wabash" and "Antietam" class, the *berth-deck clamps* fill the space amidships, between the thick strakes and lower side of berth-deck beams; the gun-deck clamps fill the space amidships between the berth-deck water-way and the under side of the gun-deck beams; the spar-deck clamps fill up the space between the lower side of the upper *port-sills* and lower side of spar-deck beams.

In vessels of the "Omaha" and "Congress" class, where iron hanging knees have been substituted for the wooden ones under the forecastle and poop-decks, a shelf-piece has been worked instead of the upper strake of clamps; and in the length of the ship, occupied by the engines and boilers, the upper strake of *berth-deck clamps* has been made considerably thicker than the others, iron hanging

knees being used in that space; but in no other cases are shelf-pieces used at the present time. The strakes of clamps are scarphed or plain butted, (there being a difference of opinion between construction, as to which is preferable,) and carefully cut over the diagonal braces, so that they lay close to the frame; enough short fastening is put in to hold the clamps to their place, until the outside planking is put on. After three or four strakes have been worked, they are bolted edgewise in every room, and riveted on rings on the lower edge of the lower strake, the remaining strakes are put in after the decks have been framed, and water-ways put in. Locust or Lignumvitæ keys are driven in the scarphs, and the strakes have keys driven in tightly about four feet asunder, one-half the width of the key being cut out of each edge of the adjoining strakes.

Great care has to be taken, to see that no butt of any inside plank comes on the same frame, and opposite to a butt of the outside planking.

All *short fastening* for any inside work is driven near the edge of the plank, but in the middle of the timber, so as not to interfere with the fastening from the outside, as all through-bolts from the outside will rivet on these planks.

The length of the *short fastening* is about $2\frac{1}{2}$ times the thickness of the plank through which it is driven, but in no case are they to go through the frame by one inch, after being punched in one-half inch from the face of the plank.

BILGE-STRAKES.

Bilge-strakes are strakes of heavy white oak or yellow pine plank worked over the floor-heads and first futtock-heads, running the entire length of the vessel.

In the "Antietam," there are two strakes over the floor-heads, filling the space to the outer keelson, and four strakes at the first futtock-head. Each strake is temporarily fastened with one iron bolt, driven near the edge of the strake, but in the middle of each timber, the butts having two bolts in each. These strakes are also bolted edgewise in every room, and riveted on rings, on the lower edge of the bottom strake.

THICK STRAKES.

The *thick strakes* are the same thickness as the *bilge-strakes*, but are worked over the abutments of the second and fourth futtocks; in the "Antietam" they are three in number, and are secured to the frame, and bolted edgewise, the same as the bilge-strakes. All the *thick strakes* rise with the heads and heels of the timbers, and abut under the berth-deck clamps.

CEILING.

Strakes of white-oak plank, called *ceiling*, are worked between the bilge-strakes and thick strakes, and thick strakes and berth-deck clamps about one inch less in thickness amidships, and short fastening enough is put in to hold it to its place, until the outside or bottom plank is worked. The projecting edges of the bilge and thick strakes are *chamfered.*

Fifth Lecture.

Subjects;—Outside Planking, Main Wales, Channel Wales, Middle Wales, Sheer Strakes, Outside Battery Plank, Garboard Strakes, Bottom Plank, Preparations for, and method of Planking, Fastening of the outside Planking, Deck plans, Deck beams, Knees used to secure the beams to the side of the Ship, Fastening of the Knees, Regulating the Beams, Framing of Decks, Carlings, Framing of Mast partners, Ledges, Waterways, Deck thick strakes, Framing of Hatchways, Spirketting, Inside Battery Plank, Deck Stringers, Deck Plank, Stantions.

OUTSIDE PLANKING.

The *outside planking* in square sterned ships terminates *abaft* below the wing transom, or gun deck hook, in the rabbet of the stern-post, on the wing transom at the margin, or at the kunckle of the stern timbers, and above the wing transom or kunckle, at the *after edge* of the side counter-timber, and forward in the rabbet of the stem.

In vessels with round or eliptical sterns the outside planking terminates *abaft* in the rabbet of the stern-post below and above in the rabbet formed by a projection of the centre counter-timber, or when the vessel has a propeller well, by allowing the counter timbers that form the side of the well to project below far enough to form a rabbet, above the projection of the centre counter-timber, the plank run entirely around the stern. [See Antietam.] The length of the ship is too great for the strakes to be obtained in one length; each strake is, therefore, composed of several, and the place at which they meet lengthwise is called the *butt*; the foremost and aftermost plank in each strake are called the fore and after hood, and the extreme ends where they abut against the fore part of the rabbet of the stern and after part of the rabbet of the stern post, are called the hooding ends.

When the edges of the strakes curve up or down, they are said to *hang* or *sny;* if down to hang, and if up to sny.

The strakes are not parallel, but of such a breadth as the form, the place where they are situated, and the circumference of the body at any given distances upon them, may require; narrowing at some places, and widening, technically called *fanning*, at others, according as the body requires the form of the edges to hang or sny.

The principle strakes or assemblages of strakes that compose the exterior planking on three decked ships of war, are the *channel wales*, *middle wales* and *main wales*, in two decked ships of war, such as the "Wabash," and "Franklin," the *channel wales* and *main wales;* in Sloops of War and all single gun deck ships, such as the "Omaha" and "Antietam," the *main wales* only. Note.—Channel wales are often called *strings*. The other principal strakes which all ships have, are *sheer strakes; bottom plank,* and *garboard strakes*.

MAIN WALES.

The *main wales* are an assemblage of planks placed upon the widest part of the body, extending the whole length of the vessel from the lower port sill of the gun-deck to the bottom plank; they are the thickest planking and from one of the principal longitudinal ties, as much from their situation as their substance. The fastening of the principal deck pass through them. The *first seven strakes* below the gun-deck port sills in all our Steam Sloops of War and Frigates, from abreast the *foremast* to abreast the *mizzen-mast*, are worked $1\frac{1}{4}$ inches thicker, and *jog* that much between the frames, for which the edges of the timbers are carefully trimmed and sometimes a *rabbet* is cut for it on the *beveling edge* of the timbers. The upper edge of these strakes which project into the room are *chamfered*, that dirt may not lay on it. The thickness of the wales diminishes gradually from abreast the foremast and mizzen-mast to the stem and stern. In like manner, *two* strakes between the 2nd and 3rd *futtock heads* are increased in thickness $1\frac{1}{4}$ inches amidships and *jog* that much between the frames. From the port sill to the light water line the *wale strakes* should not exceed *eight* inches in width for vessels of the "Omaha," "Wabash" and "Antietam" class, increasing gradually in width not exceeding *twelve* inches under the flat of the bottom.

The *plank under the bottom* and all those subject to compression are in length from 35 to 40 feet but the *wales, clamps* and spirketing, which are subject to extension, should be the longest plank, and are from 40 to 50 feet in length. In squaring off the timbers in planking the bottom, the round of the moulding edge should be preserved and whatever may be necessary to take away that the plank may lay solid against the timber should be taken out of the plank.

CHANNEL WALES.

The *channel-wales* sometimes called *strings*, consist of thick strakes placed between the spar and main deck ports in ships of three decks, and gun and spar-deck ports in those of two decks; they receive the chain and preventer plate bolts, and are intended to give strength to the top side or upper works. These strakes are increased $1\frac{1}{2}$ inches in thickness and jogged between the frames as far foward and aft as good work can be made. In working the wales they are kept clear of the port sills about $\frac{3}{4}$ of an inch to form a stop for the port-shutters.

MIDDLE WALES.

The *middle-wale* consists of thick strakes, in three-decked ships placed between the main and lower gun deck ports, giving additionalstrength to this class of ships.

SHEER STRAKES.

The *sheer strakes* are the first strakes worked, being the upper strake of main wales and upper and lower strake of channel wales or strings. The lower strake of channel wales or strings and sheer strakes of main wales can be seen on "the model of the "Antietam in frame."

OUTSIDE BATTERY PLANK.

The different strakes that come between the ports are named according as they are situated; if in range of the gun deck ports, they are called outside gun deck batteries; if in range of the spar deck, outside spar deck batteries.

GARBOARD STRAKES.

The *garboard strakes* are the two strakes next the keel on each side, and are made thicker than the rest of bottom plank. In the construction of many of our naval vessels and in the one before you, ("Antietam) the garboard strakes, two in number on each side, were secured to the keel previous to raising the frame; they could be worked much better at that time and they made a good support for the frame in raising it. The strakes diminish gradually in thickness falling in fair upwards with the bottom plank and forward and aft these strakes likewise wear into the thickness of the running plank of the bottom.

BOTTOM PLANK.

The bottom plank may be considered as the planking from the main wales to the garboard strakes, and should not exceed twelve inches in width. The thickness of the plank diminishes gradually from the thickness required for the wales to that for the bottom plank.

PREPARATIONS FOR, AND METHOD OF PLANKING.

Before commencing to plank a ship, a representation of the plank, or, as it is termed, a shift of the butts of the plank, should be made on a board by the draughtsman, who, in making it must have reference to the stock of plank in store before he determines the lengths of the plank or shifts to be made in planking the vessel, this board is furnished to the foreman of carpenters as a guide for him to work by. The best shift of butts of plank that can be made, is to have *twelve* strakes between butts on the same frame; and in no case should these be less than *four* strakes.

The best plan yet adopted, is to have a half model of the vessel made to a scale and painted white; and on this can the position of all the gun ports; air ports, scuppers, valves connected with the engines and boilers that will come through the bottom or side; diagonal bracing, lengths, widths, and shift of butts of planking, be marked, also the height of the line of copper fastenening and copper sheathing line: models of this description are used in our navy yards and those which were used in building the Sloops of War "Omaha" and 'Congress," are now in the Seamanship Room.

Before commencing to put on the plank, thin broad battens called sheer battens are nailed around the ship at the sheer heights, and when properly regulated, the line is razed or cut in across each timber; and it is to this line, that the edge of the sheer strakes and wales are first set. The lower strake of strings and sheer strake of wales are shown on the "Antietam's" model.

A strake of plank can now be worked near each of the ribbands, and when on and fastened, the ribbands can be removed and several gangs of workman can be employed advantageously in getting out, and working the remainder of the plank, required to fill up the openings.

In working the bottom plank and wales the endeavor of the builder should be to bring the plank to the timbers without forcing it upwards to the edge of that already worked: or in other words, edge sets should be used as little as possible, as the planking that would bear bending one way may be easily broken by an attempt to force it in an opposite direction. Moreover in working the plank, should the edges be bruised and the bruised portions not removed, early decay will be likely to ensue from the injury that the grain of the wood has received. One reason why the butts of plank are often found to be decayed before the other portion, is, that in working the plank it is required to be forced towards the plank ahead of it, in order to diminish the opening of the butt, with a heavy sledge hammer and the grain of the wood being bruised, early decay ensues. In working the first strakes of planking the sirmarks are the best guides to run the strakes on by, as they all give a normal or natural line and the intermeditate strakes if properly lined and worked will require little if any edge set. Where the plank requires considerable bending to make it fit to its place, it is got out to the proper shape and bevel, and then placed in a steam-box and steamed until it can be bent readily to its place, when it is taken out and worked. Enough short fastening is put in the plank as it is worked, to hold it to its place, as it cannot be fastened for good, until the inside planking, water-ways, thick strakes of deck and knees are all worked, as all the through fastening from the outside will rivet on these planks and knees.

UPON THE FASTENING OF THE OUTSIDE PLANKING.

As naval vessels have all the *outside planking* strings, wales and bottom *plank* double or square fastened; I will describe the manner in which the "Antietam" is fastened, which will answer for all.

All the outside *planking*, ~~strings~~ wales and bottom *plank*, will be double or square fastened, that is there will be two through and two short fastenings in each frame.

The length of the short fastenings will be about $2\frac{1}{3}$ times the *thicknees* of the plank through which it is driven, but in no case are they to go through the frame timbers by one inch, after being punched in one half inch from the face of the plank; all through bolts of whatever kind are riveted on rings. Whenever a knee bolt a waterway, or hook bolt, or any through bolt will take its place, the fastening from the outside is omitted.

In the frame next on each side that or which the plank butts, in lieu of one of the short fastenings, in the timber next the butt there is a through bolt placed called a butt bolt.

In the hood-ends forward and aft, when they can be got through, through bolts will be driven and riveted on alternate sides. When

the plank is reduced in width to six inches one-half of the short fastenings are omitted and the remainder is placed in the alternate edges.

The copper fastening in the "Antietam" extends up to within six and one-half feet of the lower port sill, above which, it is all of iron, except the counter immediately over the propeller, which is copper fastened.

The battery *plank* between the ports will have *one* through bolt and *two* short fastenings in each frame, called cross fastening; but the frame next the ports are square fastened; care must be taken to *keep* the fastenings in these *strakes* clear of the *gun tackle bolts.*

Below the copper fastening line *treenails* made of seasoned Locust are sometimes used; two treenails, one through bolt and one short fastening are put in each frame, above the copper line two through bolts and two short fastenings of iron are always used. If treenails are used, *five strakes of plank* on the turn of the bilge for the length occupied by the Engine and Boilers, should have two treenails and two through bolts in every other frame. All treenails are *caulked* outside and wedged on the face of the inside *plank.* The *heads* of all bolts driven from the outside should be carefully trimmed and driven home with a swedge or punch so as not to bruise the *plank;* no *plugs* are put over the heads of bolts outside below the lower port sill.

Where the *fillings* are of sufficient size, or the *floor timbers* fill the space, the *plank* is fastened to them with additional treenails or bolts.

White oak is used for the strings, wales, bottom plank and garboard strakes; yellow pine generally, for the outside battery plank.

The methods of working plank, denominated *top* and *butt* and *anchor stock,* is never carried out in this country; many years ago, this method was practiced in England, where a great scarcity of timber of the proper length for plank existed; but few, if any vessels, are planked in that way in European countries at the present time.

After the vessel is planked, the projecting edges of the strakes are all trimmed off, called *squaring off,* the seams are caulked by the caulkers, and afterwards *planed* smooth and fair and a coat of *paint* or *oil* put on, to keep the air from it and prevent its rending or splitting

Having completed the *outside planking,* we will go on board again and proceed with the various operations of putting in and securing the ends of the deck beams; framing of decks; putting in waterways and deck thick-strakes; framing of hatches and laying of deck plank.

DECK PLANS.

Before the beams can be worked out and the decks framed; a *plan* must be made for *each deck;* for example, notice the *Gun Deck Plan* of the "*Antietam;*" showing the location of the beams, half beams; framing for bowsprit bitts; mooring bitts; mast partners; nippers; capstan; chain pipes; pumps; coal scuttles and towing bitts; fore and aft pieces for hatches; carlings; ledges; deck hooks; lodging and bosom knees at ends of beams, and to fore and aft pieces of hatches and mast partners. On the *starboard side* of this *deck plan,* the framing of the parts mentioned above is shown, and the location of the *deck beams* with regard to the *joints* of the different frames, can be readily ascertained, and their position marked to correspond on top of the *deck clamps;* on the *Port*

side the *deck plank* is represented as laid, showing also the waterways and *deck thick strakes*, with proper *shift* of *butts;* position of *hawse pipes, manger board, nippers, water closets for officers and men, gun ports, coal scuttles, pumps, mast combings, bitts* and *sill pieces for the bulkheads to cabin and rooms inside, coamings and head ledges of hatches.*

That portion of the *deck* framing on the Port side, and inside of the fore and aft piece of the Boiler and ~~Engine~~ Hatch, represented by *ticked lines*, is framed in such a manner, that it can be removed readily to put in the boilers.

DECK BEAMS.

Deck Beams are made of Yellow Pine, White Oak, Hacmatack and White Pine. Yellow Pine or Oak is used in preference to the others for all the beams of the Berth, Gun and Spar Decks, but Hacmatack is sometimes used for the short beams of these decks forward and aft, also for the Forecastle deck; White Pine or Hacmatack is used for the Poop-deck beams

They vary in *siding* and *moulding sizes* according to the dimensions of the vessel and the weight of the battery to be carried on the deck In the "Wabash" and class, the dimensions for beams are as follows:—Berth-deck, 16 × 13 inches; Gun-deck, 17 × 14½ inches; Spar-deck, 16 × 13 inches. In the "Antietam" and class, Berth-deck, 13½ × 11½ inches; Gun-deck, 14 × 12½ inches; Spar-deck, 12½ × 8½ inches. Congress and class, Berth-deck, 13 × 11 inches; Spar-deck, 14 × 12½ inches. The beams are moulded *one* inch less at the ends than at the centre [In the dimensions given above the *siding size* is given first] The beams to the engine and boiler hatches and those next forward and aft of the fore and main masts are made an inch or two larger than the others in siding and moulding sizes.

The *Deck-beams* have to hold the sides of the ship in their places, and prevent them from parting. To make the most effectual combination of the beams with the sides of the ship is of the first consequence, both as regards the safety of the ship and the comfort of the officers and crew, since upon this strength the transverse strength chiefly depends; for it has to sustain the whole force and working of the side, when acted upon by the weight of the guns, stress of the masts when under a press of sail, and pressure of the water when the ship is inclined by the force of the wind or rolling. The stresses that act upon the side of the ship have a tendency principally to separate the sides from the beams, and to cause successive variation of the angle formed, transversely, by the side of the ship and the beams, which produces the working.

To give the best disposition to the fastenings that form the combination of the side with the beams, so as to oppose the greatest resistance to separation, they must be placed as much in a line with the beams as practicable, for they will be acted upon by a greater force, in degrees proportionate to the distance they are above or below them.

To prevent working, such modes of security should be applied, that while they oppose the change of form, they may resist when

motion takes place, the alteration bringing a transverse action on the fastenings, which soon destroys the compactness of the connection.

The stations of the beams having been marked on the top strake of clamps, the length of each one is obtained by first stretching a line across the ship at their several stations and then sliding out the arms of a rule made for this purpose, called a *sliding rule* until the ends touch the inside of the timbers of the frame; care being taken to keep the rule up to the line. The lengths of all the beams can be marked on this batten before any of them are marked from it. The *ends* of each beam are cut to the *bevel* or *angle* made by the *line* and *inside* of the *timber* in a vertical direction called the *up and down bevel* and the *angle* made by the *line* and *inside* of *timber* in a fore and aft direction, called the *fore and aft bevel*. The bevels as they are taken are marked on a board called a *bevel board*.

The beams are now cut to corresponed to the lengths and bevels just obtained and when completed they are carried to the vessel and placed at their stations on the clamps. The *Berth-deck beams* are generally got in place first.

The ends of the beams are *dove-tailed* down into the clamp from *one* to *one and a half inches*, the *dove-tailed tenon* being cut on the lower side of the beam and the corresponding *mortise* out of the clamp. When the dove-tails are cut the beams are driven down into them and *two* bolts driven down through it into the clamps.

TWO PIECE BEAM.

It sometimes happens that the longest beams for vessels of the Wabash and Franklin class, have to be made in *two* pieces; in such a case the scarph is *vertical* and in length *one-third* the whole length of the beam, the nibs of the scarphs are cut in only *one-third* of their thickness or about *two* inches. The lips of the scarph has two rows of seasoned oaks $12 \times 8\frac{1}{2} \times 2\frac{3}{4}$ inches, about 12 inches asunder let in on the alternate edges; fastened with *iron* bolts about $1\frac{1}{4}$ inches in diameter, about 15 inches asunder and *set up* with *nuts* and *washers* The nuts are secured with small bolts or spikes. A, in Figure 60, *Text Book*, is a good illustration of a *two piece beam*.

KNEES USED TO SECURE THE BEAMS TO THE SIDE OF THE SHIP.

The mode of securing the *beams* to the *side*, in general use, is by *lodging, lap and hanging knees*, where *one* of each is placed to every beam end. The *hanging knees* are secured to the underside of the beam and to the side of the ship, with the plane of its side vertical or in the same plane with the side of the beam. That part of the knee which lies under and against the beam is called the *arm*, and the part which lies against the clamps or side, the body. The lengths of the *arms* in vessels of the "Antietam" class should not be less than $4\frac{1}{2}$ feet and the bodies 6 feet for those under the Berth-deck beams; the bodies of those under the Gun-deck beams should reach

the Berth-deck waterways and the bodies of those of the Spar-deck beams should reach the spirketting of Gun-deck.

The *lodging knees*, [as seen in the Gun-deck plan or model of "Antietam,"] are secured to the forward side of the beams, lying with its body on top of the clamp and *fayed* out against the inside of the frame. The *lap* or *bosom knees*, are seen secured to the opposite side of the beams, *fayed* to the inside of the body of the lodging knees.

When a beam comes over a port, so that the plane of the side of the knee could not be in the same plane with the side of the beam without lying before it, the knee is brought with the plane of its side diagonally from the beam, when it is called a *dagger knee*.

In the "Wabash," "Merrimack" and class the *knees to the beam ends* are disposed as follows:—the Berth-deck beams have one lodging and one dagger knee to each end of every beam, in addition to which the partner beams of the mainmast and the one next on each side of it has a *hanging knee* at each end. The dagger knees incline from the *aft side* of the beams which are forward of the middle of the ship, and from the *fore side* of the beams abaft. The *throats* of these knees are trimmed so as to look *fore and aft*, that is in a parallel direction with the bottom of the beam, and with the clamps so that the lower corner on the *arm* will not hang below the beam.

The *Gun-deck beams* have two lodge and one hanging knee to each end of one beam and two dagger knees at each end of the next beam; the bodies of hanging and dagger knees, run down to the waterways and against the hanging knee. The Spar-deck beams, are kneed off precisely the same as those of the Gun-deck, with the exception, the hanging knees of this deck are over those beams of the Gun-deck which have two dagger knees. By this method every other beam has three knees at each end.

The ends of the dagger knees *mitre* against the hanging knees.

The knees are of White Oak and Hæmatack, and vary in *siding size* according to the dimensions of the vessel and location of them.

THE FASTENINGS OF THE KNEES.

The *arms* of the knees when practicable have two round coaks in the beams *three* inches in diameter. The *bolts* that fasten the bodies of the knees are distinguished as *in-and-out bolts* in the hanging knees are generally *seven* in number, including the *throat bolt*. The bodies of the lodge and lap knees have *one* bolt in each timber of the frame that they cross, also *one* bolt through the lodging knee into the clamp opposite each opening of the frame. The *arms* of the hanging knees have not less than *five* bolts driven from the top of the beams and riveted on rings on the knees. The *arms* of the lodge and lap knees have not less than *five fore and aft bolts* driven and riveted on rings on alternate sides of the *arms of the knees*.

All the in-and-out bolts are driven from the outside of the *wales* and riveted on rings on the face of the knees, excepting the *throat bolts* which are blunt bolts, and are driven from the face of the knees.

The knees of the Orlop-deck beams, and sometimes those of the Berth-deck when below the copper line, are fastened before the vessel is planked outside, as it saves considerable expense, *iron* fastening being used instead of *copper*, driven from the outside of frame; when *iron hanging knees* are used for the Berth-deck beams in the space occupied by Engine and Boilers, the *in-and-out* bolts are of *iron* driven from the outside of frame and riveted on the knees.

Within the past three years, *iron hanging knees* have been used for vessels with light spar-decks.

In a *side wheel steamer*, the deck beams which project beyond the side of the vessel forward and aft of the paddle-wheels and forming the foundation on which the guards and paddle-boxes rest are called the *guard beams* the outside of the paddle-boxes is supported by the *spring-beams*, the ends resting on and secured to the guard beam next forward and aft of the wheels. The guards are supported on the outside by hanging knees, and heavy iron rods called *guard braces*.

REGULATING THE BEAMS.

The beams being in and secured, are temporarily *shored up*, that is, temporary stantions are placed under the centre of each beam, commencing with the *Berth deck* which are shored from the top of the keelson, and the tops regulated; the beams of the decks above are shored and regulated from those next below. The *spring* or round up of beams varies from 3 to 6 inches in the "Wabash" and "Antietam's" decks.

FRAMING OF DECKS.

The *deck framing* which in addition to the beams and half beams consists chiefly of *fore-and-aft pieces for hatchways*, *carlings* and *ledges*, should now be put in according to the plans furnished for the several decks.

The fore-and-aft pieces of the engine and boiler hatches are first put in place in order that the *half beams* which have their midship ends let into and supported by them, may be put in place. By reference to the model of "Antietam," it will be seen that the *half beams* are secured to the *fore-and-aft pieces* with a *lodging* and a *lap knee* on the *outside*, at the end of each beam; and an *iron* knee is placed on the *inside* of the fore-and-aft piece in either corner of the hatch, and securely fastened through the beams, *fore-and-aft pieces* and *knees*, the bolts being driven and riveted on alternate sides.

The *fore-and-aft pieces* for the remaining hatchways, carlings, framing for bitts, mast partners, nippers, capstans, chain pipes, pumps, &c., are now let down between the beams with a double jog or shoulder; being cut in on top, from *one and one eighth to one and one-half inches* from the face or side of the beam.

CARLINGS.

The *carlings* are in tiers ranging fore-and-aft between the beams and vary in number and size according to the deck and dimensions of the vessel. In the model of the "Antietam," there are four tiers, the inside ones are kept nearly in line with the fore-and-aft pieces for the

hatchways The outside tiers are arranged in a *curved line* keeping nearly parallel to the inside of the frame; this adds to the appearance of the deck frame and makes the most economical distribution of timber, inasmuch as the equality of lengths which there will be in the *ledges* is a saving of timber. The carlings are of Yellow Pine and Hacmatack.

FRAMING OF MAST PARTNERS.

The framing around a mast-hole where wedges are used, is composed of fore-and-aft partners, cross-partners and corner chocks, they are of White or Live Oak. The ends of fore-and-aft partners are let down into the beams and have a *lodye* and a *lap* knee on the outside securely fastened to them. *Coamings* are placed around each mast hole and fastened to the partners.

The framing or fore-and-aft stuff forming the beds for bitts, nippers, capstan and chain pipes are generally of White or Live Oak. The fore-and-aft pieces of hatches of White Oak or Yellow Pine.

In many of our vessels the fore-and-aft pieces to the hatches are secured with a *lodge* and *lap knee*.

LEDGES.

The ledges are of Yellow Pine or Hacmatack and placed between the beams in this case, ("the Antietam," there is but *one*, but many vessels have *two* between each beam, especially where a heavy battery is to be carried; they extend from *carling* to *carling*, and from *carling* to the *throat* of the *knees*, lying parallel to the beams, and with a common distance between them; they are cut in on to the carlings with a *double joy* a little less than the carlings are on to the beams.

The various operations of putting in the water-ways, thick strakes and framing of hatches may now be proceeded with.

WATERWAYS.

The *waterways* are pieces lying in the angle made by the top of the deck beams and inside of the frame timbers, extending the whole length of the ship, they are *leveled off* on their face, on the Gun-decks, from the thickness of the spirketing, to that of the thick strakes, in order that the forward gun trucks may lay closer to it and thus allow of more *lateral train*.

On the Berth-deck the inside edge is square and projects above the thick strakes. The pieces forward and aft where there is considerable shape, they are of White or Live Oak, the remainder are of Yellow Pine. In some cases the pieces are joined together with a *vertical scarph*, but generally abut each other, They are *dove-tailed* down over the ends of the beams *two* inches and secured with one up-and-down bolt through each beam, one between the beams through the knees into the clamps, and one in each beam driven at an angle into the frame.

DECK THICK STRAKES.

The *thick strakes* are the first two or three strakes next inside the waterways and are generally about two inches thicker than the deck plank; in the "model" they extend from about *twenty* feet before the fore-mast to *twenty* feet abaft the mizzen mast. They are either *jogged* or *dove-tailed* down *two* inches over the beams; the entire depth of the

rabbet or dove-tail being cut out of the beam, but on the ledges, there is one inch taken out of the thick strakes and one inch out of the ledges. In the vessels there are three strakes to each deck; the strakes of the Spar and Gun-deck will show no projection above the deck plank, but on the Berth-deck, they *dove-tail* or *jog* down *one and one-half inches* into the beam and project *four and one-half inches* above the Berth-deck plank.

These strakes are secured with two bolts in each beam, and two spikes in the ledges; also, with one bolt through every other frame, driven from the outside through frame and waterway, and riveted on rings on the projecting edges, above or below the deck as the case may be, so that in repairing the vessel they can be easily backed out.

FRAMING OF HATCHWAYS.

Hatchways are framed of four pieces, two placed fore-and-aft, called *coamings*, and two placed athwartships called *head ledges*. The head ledges rest on the beams and the coamings on the fore-and-aft pieces placed there for that purpose reaching from beam to beam. The fore-and aft pieces are worked *three* inches wider than the *coamings*, to form a support for the strake of deck plank that comes on it.

The coamings and head-ledges are chimed in above the deck to form a water course around the hatchway, and are reduced in thickness at the top. The *head-ledges* and *coamings* are *cocked* to the fore-and-aft pieces and beams with round coaks, and when of more than one piece in height above the deck, to each other. The corners of them are dove-tailed together, as shown in the "model;" they are secured with one bolt through each corner and about *eighteen* inches asunder through the head-ledge and coamings, being riveted on rings on the under side of beams and fore-and-aft pieces.

The height of the coamings varies in different ships and on different decks; those on the Gun-decks are always the highest and are from 26 to 30 inches in height.

The coamings have a rabbet taken out of them to receive the gratings; on the Spar-deck iron canopy rails are fitted to the forward hatches and brass to those of the Cabin, Ward Room and Stearage hatches

When the hatchways are covered as is the case with the Cabin hatch of the Yacht "America" the covering is called a *booby hatch*.

SPIRKETTING.

The spirketting are composed of thick strakes lying immediately above the water-ways on gun and spar decks, filling up the space from the water-way to port sill. On the berth-deck there are generally three strakes under the beams called clamps and from that to the water-ways is called ceiling.

INSIDE BATTERY PLANK.

The space between the clamps and spirketting on the gun and spar decks is filled in with oak plank called inside-gun or spar-deck batteries. Note—Before the hanging-knees are placed under the beams the water-ways, spirketting and ceiling between gun and berth-decks must be worked, as the bodies of the knees come over these strakes and fasten through them.

DECK STRINGERS.

Just outside of the coamings of the hatches, on the gun and spar decks there are generally three or four strakes of plank worked one inch thicker than the deck plank and jogged that much over the beams, a rabbet being cut on the beam and the plank carefully fitted over it; the score to be taken out of the ledges and not from the plank; these strakes are called *deck stringers*

In some cases a *round coak* is put in each strake where it crosses the beams. The Gun-tackle bolts and Stopper bolts are generally placed in these strakes. In some cases they are of White Oak, but generally of Yellow Pine, the same as the rest of the deck plank.

DECK PLANK.

The *deck plank* fill up the space between the deck stringers and thick strakes at the sides and between the hatches amidships. The strahe running directly through the centre of the deck is generally one-half an inch thicker and wider than the rest, the projection being above the deck, the *stantions* which support the deck beams rest. step upon it.

The deck plank is fastened with *two* spikes in each beam and *one* in each ledge that the strake crosses.

STANTIONS.

The *stantions* under the Gun and Spar deck beams are of Locust or White Oak, fitted with an iron *shoe* and *cap;* those under the beams in the Ward Room and Cabin are of *iron* from 2½ to 3 inches in diameter, and are generally placed *one* on each side, inside of the line of the bulkheads of State Rooms; leaving a clear space for the table in the centre. these stantions have metal caps and shoes. Those in the vicinity of the capstan are also of iron, hinged above and made to throw up and secure above when the capstan is in use; those to the Berth-deck beams are made square and rest on the centre keelson the heel being tenoned into the capping, and a wooden cap under the beam, the head of the stantion being tenoned into it; the cap is spiked to the beam when the stantions are in place; the metal caps and shoes are secured with large screws to the beams and centre strake of deck.

Sixth Lecture.

Subjects:—Scantling Rule, Bowsprit Bitts, Mooring or Cable Bitts, Top-sail Sheet Bitts, Towing Bitts, Orlop Deck, Bulkheads, Poop and Top-Gallant Forecastle Decks, Number and Names of Decks, Bulwarks, Hammock Nettings, Hawse Holes, Manger Board and Manger, Scuppers, Air Ports, Controllers, Compressor, Channels, Cutwater or Head, Gripe, Caulking and Coppering.

Rule to obtain the *Scantling* or *siding sizes* of the timber used in the construction of wooden vessels, by

Samuel M. Pook,

Naval Constructor, U. S. N.

Multiply the moulded breadth of beam by the following decimals for the siding size, in inches and parts of an inch, viz:

Siding size of keel,.....	.42	Deck Plank,.....	.1
Siding size of frame.....	.28	Bottom Plank,.....	.1
Moulded square at floor-heads.	...	Wales and Clamps,.....	.15
Moulded at throat.....	.42	Cable Bitts,.....	.45
Moulded at rail,.....	.16	Bowsprit,.....	.4
Gun-deck beams, .35 to	.38	Mast Partners,.....	.3
Spar " " .95 of Gun-deck.	.....	Cat Heads.....	.4
Ledges,.....	.18	Stantions in hold,.....	.22
Carlings,.....	.2	Stantions between decks,.....	.2
Ledge and Lap Knees,.....	.18	Coamings.....	.16
6 hanging Knees under beams amidships,.....	7	Timber and Room,.....	.75
Hanging Knees.....	.26		

FASTENINGS NEAR THE BINNACLES.

All the hatches, decks and knees in the vicinity of the binnacles are fastened with copper bolts and composition spikes.

BITTS.

The *Bowsprit, mooring or cable bitts, top-sail sheet and towing bitts* should all be worked out and secured in their several positions before the decks are laid.

BOWSPRIT BITTS.

The *Bowsprit bitts* are *two* in number standing athwartships and far enough apart to receive the heel of the bowsprit; a *chock* is *dove-tailed* into the bitts over the bowsprit to hold it down to its place. They are generally made of Live or White Oak, and extend from the underside of the top-gallant forecastle deck to the Berth-deck in nearly all vessels of war, being scored over and bolted to the Gun and Berth-deck beams, forward of which they are placed; between the Gun and Berth-decks they are tapered.

MOORING OR CABLE BITTS.

Sloops-of-War and Frigates are always fitted with *two pair* of *mooring or cable bitts* on the Gun-deck, extending from about *three and one-half feet* above the Gun-deck to the Berth-deck beams, being *square above* and *tapered below* from the lower side of Gun-deck beams to the heel of the bitt; they are scored over and bolted to the beams of both decks. These bitts have a heavy piece of White or Live Oak timber in front of them called *standards* or *cable-bitt-knees*, being *jogged* over the beams about *two* inches, *coaked* to the fore-and-aft pieces below and securely fastened to the bitts and beams There is *one ring bolt* placed in the throat of the standards or knees and *one* in the next beam called *chain stopper bolts* and an *eye bolt* in the fore end of the knees to hook a tackle in.

These bitts have a cylindrical iron casting over the head of them with worm flanges cast on them for the cable to rest on, and, as a support to the flanges, pieces of oak are *fayed* under them and fastened to the bitts; above the flanges a round iron pin called a *bitt-pin* is placed to prevent the cable from flying off of the bitts when veering rapidly. [Note.—Fig. 82, Text Book, is a sectional elevation of *cable bitts used in H. M. Service*, designed by Admiral Elliott, of H. M. Navy, and named after him; they are somewhat different from our own]

In many of our modern vessels, in lieu of the bitts running through the decks, *cast iron cable bitts* with *thick broad flanges* to secure them by are used. Heavy fore-and aft pieces of White or Live Oak are placed *between the beams, under the bitts*, and the bolts which secures them in place are driven from the top of the flange and riveted on *plates* or *set up* with *nuts and washers below*, above the flange on the forward side of the bitts there is a projection to receive the after ends of the supporters, but they are seldom if ever used, as they are deemed sufficiently strong without them; a *cavil* is placed through the bitt to hold up the parts of the chain and a bitt pin above to prevent the chain from flying off when veering rapidly. These *cast iron bitts* are used in connection with Brown's Patent Capstan, and will be used on the "Antietam;" the fore-and-aft pieces, to which they will be secured, can be seen in the "model," and a model of the bitts in the Seamanship Room.

The deck stopper bolts generally range with the outside of the after pair of bitts *one* being placed in each beam from the chain pipes to the cable bitts, and riveted on plates under the beams.

TOP-SAIL SHEET BITTS.

The *Top-sail sheet Bitts* are generally of Locust and extend to the deck below, tapered between decks; they should stand nearly plumb placed in the angle of the *fore-and-aft partners* and after side of beam next forward of the masts, secured to the deck beams of both decks.—The bitts should have composition *caps and corner pieces*, a Lignumvitæ cavil through the head to belay the sheet, eye bolt for a stopper in the fore side near the deck and sheived that the sheets may all *lead aft.*

TOWING BITTS.

Towing Bitts are usually of Live Oak and are placed directly abaft the Mizzen-mast, on the Main-deck, against the partner beam, they ex-

tend to the deck below, tapered between decks and secured to the beams of both decks; the heads are sometimes fitted with a cylindrical casting, but usually have composition caps, corner pieces and a heavy *bitt-pin*.

ORLOP DECKS.

The *Orlop Deck* beams require no clamps to rest on; the ends of the beams fay against the timbers and thick-strakes, having in large vessels; *one* lodging and *one* hanging knee at the end of each beam, fastened through the bottom with copper and through the beams with iron bolts.

The hatchways of this deck are usually closed with tight hatch covers provided with iron hatch bars to secure and lock them up.

In vessels having no regular Orlop deck, (of which the "Antietam" is one,) light Yellow Pine beams are *fayed* against the thick-strakes or ceiling with fore-and-aft pieces let in between, instead of a lodging knee, for the purpose of holding the edge of the deck plank up, and on these a light White Pine deck is laid. There is also a deck of White Pine about three inches in thickness laid on top of the keelsons on either side of the main keelson from the engine space forward and aft. In the space occupied by the boilers this is used to set the boilers on; *forward*, it answers for the *flooring* for the *shell rooms*, *magazines* and *chain lockers*; *aft*, for a *flooring* for *after hold magazines* and *shell rooms*.

In the fore hold and space occupied by boilers, short plank are placed between the sister and side keelson, called limber boards,

A bulkhead is usually run up on either side of the *shaft alley*, and a light deck placed over head, on this deck forward and aft, store rooms for various purposes are built.

BULKHEADS.

Bulkheads are sometimes used to give transverse strength to the ship and divide her into *water tight compartments*. A *water tight bulkhead* is placed in the *fore part* of all our modern built war steamers; it extends up as high as the Berth deck made of two thicknesses of Yellow Pine plank crossing each other at opposite angles, being bolted and riveted on rings on alternate sides and sustained by stantions on the after side, the seams are caulked and payed on both sides; fitted with a valve and rod on either side of the sister keelson, to let the water run to the pumps.

Bulkheads of lighter construction, and capable of being removed when required, are used to enclose state-rooms, cabins, etc., and to separate apartments in the ship.

Longitudinal or *fore-and-aft bulkheads* are used to add to the longitudinal strength of the ship. They act like the web of a girder, to resist longitudinal rocking and bending.

POOP AND TOP-GALLANT FORECASTLE DECKS.

The deck beams of the Poop and Top-gallant Forecastle deck rest on a *shelf piece* instead of clamps, with clamps below. The ends of the beams are bolted through this and secured to the side with a lodge and a lap knee of wood, and an iron hanging knee under the beam. A *tenon* is cut on the head of each timber in the length of these decks and an oak plank somewhat thicker than the deck plank called a *planksheer*,

is worked out to the proper shape *mortised* to receive the tenons and bolted to the heads of the timbers.

The forward beam of the Poop and after-beam of the Top-gallant Forecastle decks, called a breast beam is moulded and sided larger than the others and rabbeted out to receive the ends of the deck plank and projects above the deck the same distance as the plank sheer; the projection of both is coved out to form a water course. The beams of these decks are supported by round iron stantions fitted with caps and shoes. On top of the plank sheer a solid piece of oak called a *chock* is sometimes worked and on top of this a light *iron rail* is placed, the heels of the *rail stantions* being screwed into the chock; over these stantions and rail a cloth of canvass is sometimes placed.

NUMBER AND NAMES OF DECKS.

Decks in ships of different sizes and proportions, vary in number from *one* to *six*.

The ship is said to be *single decked, two decked or three decked* according to the number of those decks only which are above the load-water line and complete from stem to stern.

In three-decked ships the lowest deck above water is called the *Gun-deck*, the next above is the *Middle-deck*, the next, the *Main deck*, the next, the *Spar-deck*.

In two-decked ships, the lowest deck is the *Gun-deck*, the next above, the *Main-deck*, the next, the *Spar-deck*.

In Frigates, the lowest deck is the *Gun-deck*, the next above it, the *Spar-deck*.

Sloops-of-War usually have but *one* deck with guns on it, called the *Spar-deck*, unless the deck is covered as is the case in the "Congress" and "Antietam" class, when it is called the *Gun-deck*, the next above, the *Spar-deck*, and the next below the *Berth-deck*.

The deck below the Berth-deck is called the *Orlop-deck*, in Frigates and Sloops-of-War.

Sloops-of-War having covered Gun-decks are called *Corvetts*, among which may be mentioned the "Antietam," "Congress" and "Savannah"

In the old line-of-battle ships, the decks below the *Gun-deck* was called the *Orlop* or *Berth-deck;* below that the *Cock-pit*.

If a ship has not a top-gallant forecastle or poop, her *Spar-deck* is said to be flush.

Side-wheel steamers have a raised platform extending from side to side, amidships, between the paddle boxes, called a *Hurricane-deck*.

The narrow platform placed athwartship and level with the tops of the wheel-houses, in side-wheel steamers, and above the hammock netting, forward or abaft the main-mast; in screw steamers, is called a *bridge*.

The clear height between decks, is measured from the upper surface of the planking of one deck to the under side of the beams of the next deck above, it is seldom less than six feet.

BULWARKS.

Bulwarks are those parts of the ship which rise above the spar deck. The waist, quarter deck and forecastle, or the flush deck of all ships of war have close bulwarks, their vertical framing consists of the top-timbers of the frame. The outside and inside of the bulwarks of a man of war are usually planked.

Along the top runs a piece of heavy plank called the main rail at the waist of a ship, and the plank sheer at the poop deck and top-gallant forecastle of a ship with a waist, and throughout the whole length of a flush decked ship. In the "Antietam" and class there is no main rail, the piece placed over and secured to the top timbers between the poop and top-gallant forecastle being called the spar-deck plank-sheer, it has a projection outside and inside, with a moulding worked on the outside edge and a corresponding moulding is put on forward and aft to carry out the sheer line. In vessels of the Wabash, class or any of those without light upper decks, the piece lying over and covering the edges of the inside and outside planking and top timber heads, from the top gallant forecastle to the poop deck, is called the main-rail, it projects beyond the outside and inside planking the same as the plank sheer spoken of above, having a moulding worked on the outside and inside edges, and corresponding mouldings are put on forward and aft, to carry out the sheer line and make it look symmetrical.

The plank sheers and main rail are secured by cutting a tenon on the head of the top timber and a mortise in the rail, or plank sheer scarphing the pieces together with vertical scarphs and fastening to the heads of the frame timbers.

HAMMOCK NETTINGS.

On top of the main-rail in vessels without, or on top of the plank sheer in vessels with light spar-decks, the hammock nettings are placed: consisting of a row of upright iron stantions having a ~~screw bolted to the rail or plank sheer~~; forked end to which the hammock rails are secured; the opening between the hammock rail and main rail being closed up on the outside, with tongued and grooved white pine boards placed vertically and panneled on the inside; where the hammock rails are cut off in the pivot-ports, gangways and break of poop top-gallant forecastle decks, pieces of walnut or mahogany plank are placed, extending up to the height of the chocks on those decks, called head-boards at the fore and after ends, and side boards in the gangway against these, the hammock rails finish. Inside the hammock nettings shifting-boards are placed to keep the hammocks off the rail and iron work; in some vessels (Antietam" for instance,) the small spare spars and lumber are stowed under them; small scuppers are cut to allow any water to pass off that should get in

A hammock cloth is secured on the outside to cover the hammocks when stowed.

The projection of the hammock nettings should be outside, so as not to interfere with belaying the rigging to the pin-rails.

HAWSE HOLES.

The *Hawse holes* for the cables are usually *four* in number in all vessels of war, and are usually placed between the cheek knees of the head, being cut through the hawse pieces, and lined with heavy sheet lead, before the heavy cast iron pipes called *Hawse pipes* are put in, these pipes are cast in *two* pieces and abut in the centre of their length; a piece called a *naval hood* is placed between the cheek knees and upon this the outside flange usually rests; the pipes are secured by fastening driven through the outside and inside flanges.

The *inside diameter* of the Hawse pipes should be from 9 to 10 times the diameter of the cable link; *thickness*, three-fourths of the diameter of the cable link.

The hawse holes are stopped when required with *bucklers*, which work on a hinge; a score being taken out to admit the link of the cable. On account of the extreme sharpness of some of our modern ships, the *after hawse hole* cuts through the cant timbers, as can be seen in the model of the "Antietam."

A *side pipe* is usually placed opposite each mast on the upper deck through which a hawser can be led.

A *hawse pipe* is also placed on each side aft for the purpose of riding.

MANGER BOARD AND MANGER.

A short distance abaft the hawse-holes on the working deck, a piece of oak plank, about *ten* inches in height and *six* inches in thickness called a *manger-board* extends across the ship, secured to the waterway and beam over which it is placed, having an iron plate on the top to prevent the chain from cutting it.

The space forward of the manger board is called the *manger*, the entire space is lined over the deck and up as high as the lower side of the pipes with heavy lead, and a scupper called the *manger scupper* is cut in the after corner on either side.

SCUPPERS.

Scuppers are holes lined with lead, cut through the waterway and outside planking, for discharging the water from the deck to the sea. On the outside of each hole a composition valve is secured called a scupper-valve, having a lip at the lower part to carry the water clear of the ships side and a lid fixed in such a way that when struck by the sea it closes and prevents the water from coming in on deck.

Scuppers should be laid off so that they will come in the opening of a frame, for which a filling must be put in previous to planking; and they should not be placed over a gun or air port below.

AIR PORTS.

Air-ports are holes cut through the sides of the vessel in the openings of the frames; there are usually one in each state room and in addition ten or twelve on each side of the berth deck (in vessels of the "Omaha and Antietam" class,) and as many as are required for ventilation and light under the poop and top-gallant forecastle decks. The holes are cut first and lined with lead, and a compo-

sition frame with a heavy glass light in it, made to open inboard and when closed secure with a thumb-screw; is fitted in outside and fastened with screws. The old fashioned plan of having an air-port plunger with the glass secured in it, and a bar on the inside to screw it out on, has been dispensed with in our modern vessels.

CONTROLLERS.

For the purpose of regulating and checking the motion of the cable as it runs towards the hawse-holes, controllers are used in connection with the bitts and berth-deck compressors.

A controller is a cast iron block, having a hollow in its upper side of the shape of a link of the chain cable. There are usually one to each hawse pipe just aft the manger board and in many cases, one directly over the deck-pipe leading to the chain locker; they are secured by fastening through the deck and fore and aft pieces and riveting on plates below.

The cable while lying on the controller tends of itself to drop into the hollow *slot*, and while there it is held by one of its links which lies flat in the hollow; but at the bottom of the hollow is a jog or short lever arm which can be raised by a longer lever, and so lift the cable out of the *slot* when it runs out until the lever is let go and the jog dropped.

COMPRESSOR.

The compressor is usualy a bent lever (iron) which moves horizontally close to the lower end of the chain pipe, on gun-deck through which the cable passes from the chain locker. It is made with a long arm, having an eye in the end to hook a tackle in, and a short counterbalancing arm, pivoting on a heavy bolt running through and riveted on a plate on the top of the deck; an iron plate is let in under the short arm and bolt, to prevent its cutting into the beam.

A strap is placed over the lever arm on one side to assist in supporting the weight of it. By hauling on the tackle at its end, it is made to press the cable firmly against the inside of the pipe, so as to moderate the speed of its running out. The usual diameter of the chain pipes is two thirds of that of the hawse-pipes.

In the beam over the chain-locker an eye-bolt is placed, for the purpose of securing the end of the cable, so that it can be instantly let go when required.

CHANNELS.

Channels are flat ledges of White Oak projecting outboard from the ship's sides, for spreading the lower shrouds, and giving additional support to the masts. The *extent of projection* is usually made sufficient to carry the shrouds some *five* inches clear of the hammock rails, either outboard or inboard. Generally, the shrouds pass outboard of the rail, but in some cases they are made to pass inboard, and are in such cases *housed* in the *hammock netting*.

Ships are often made without channels, the chain-plates being secured to the plankshear and channel-wales. [Note.—This was the way that the "Antietam" and class were first designed to be finished.]

The side-wheel gun boats built during the late rebellion, had their chain plates, in many cases, secured on the inside of the bulwarks.

The foremost end of the channels is usually so placed as to be nearly abreast of the foreside of the lower mast to which they belong. The *length* of the channels, in a fore-and-aft direction; is, on an average, about *one-half* of the length of the lowermast from *Spar deck to cap.*

One-half the length from *hounds to Spar deck* is the part usually occupied by the spread of the rigging.

The *thickness* of the *channels* is about *once and a half* that of the skin of the ship's side where they are fastened on, supposing the material to be the same.

Wooden channels are made from *one-third to one-fourth* thinner than this at the outer edge.

Channels are bolted to the ship's side edgewise with athwartship bolts at intervals of about *three* feet, driven through and riveted on rings on the inside of the vessel, and are supported from below by wrought iron knees. The plank of which wooden channels are made are tongued together at their edges and after the chain plates are fastened a *channel batten* is placed over the edge of the channel.

The chains made with links, as shown in Text Book, Fig 92, B. are seldom used at the present time, an iron strap called a *chain-plate* passes over the edge of the channel through a score, and is fastened to the side by the *preventer plate*, the bolt passing through the preventer-plate and chain-plate is called the *chain-bolt*, the one at the lower end of the preventer-plate is called the *preventer-bolt* and the one between the two, the *cradle bolt*. Under the chain-plate a small iron plate is fitted over the edge of the channel called a *chafing plate*, to prevent the chain-plates cutting further into the channel. The *chain*, *cradle* and *preventer* bolts pass entirely through the ship's side and rivet on rings or are keyed. An *eye* is worked on the upper end of the chain-plates to which the deadeyes are secured. There are usually *four* channel knees to the fore and main and *three* to the mizzen. The *ring bolts* are placed in the lower ends of these instead of every other chain plate as is frequently seen.

CUTWATER OR HEAD.

The shape of the cutwater or head of a vessel is always laid off in connection with the vessel, on the floor of the mould-loft; a mould is made to the shape as laid off having the position of the several pieces composing it and the bolts marked upon it

The pieces composing the cutwater or head, are the front piece, backing piece, lacing piece and filling pieces.

The piece on the front is called the *front piece*, the *backing piece* or when made of a knee called *knee of the head* comes against the stem; the *lacing piece* runs across the top from the backing to the front piece; the pieces in between these are called *filling pieces;* the last named pieces are of pine, the others of oak. The several pieces have a *groove* taken out of the edge and a piece inserted between them called a *tongue;* they are then bolted together edgewise, and when squared and planed off, the cutwater is raised to its position by means of a derrick and secured by driving heavy

bolts edgewise through the cutwater, stem and apron, and keying or riveting them on the inside.

To finish the head there is required, cheek-knees, brackets, naval hoods, trail boards, sponson pieces, billet or figure head, main head rail, timbers of the head, head planking, seating and berthing rails, flooring in the head and head seats. The cheek knees are pieces worked above and below the hawse holes in the angle of the bow and cutwater, and are distinguished as the upper and lower cheek-knees.

The *brackets* are a continuation of the cheek knees and are distinguished as the upper and lower brackets; the extreme ends of the brackets where it finishes in with the scroll is called the hair bracket. The sponson pieces are of pine and are placed under the lower cheek knee and bracket.

The naval hoods are the filling pieces placed between the cheek knees extending to the rabbet of the stem, on which the outer flanges of the hawse pipes rest.

The trail boards abut against the naval hoods and run up to the billet, they are carved or plain, to correspond with the finish of the billet. They are mitred where they abut the naval hoods, and are secured with screws so that they can be removed to caulk the hood ends.

The main head rail is the lowest, it extends in this case from the fore side of the cat head to the billet and is secured to the side of the vessel and through the end of the cutwater, it is a continuation of the sheer at height of lower port sill, spar deck.

The timbers of the head, are placed against the side of the cutwater, to which they are secured, their heels resting upon the upper bracket and their heads coming under and supporting the main-head-rail. A light rail called a middle rail, is sometimes worked midway between the upper bracket and main-head-rail, secured to the outside of the timbers of the head.

The head-planking, consists of two thicknesses of boards, breaking joints worked fore-and-aft ever the timbers of the head and secured to them.

The seating-rail is next above the main-head-rail running from the bow of the vessel to the billet and supported on light iron stantions, with a shoulder worked on them at both ends and the bolt running through and riveting on rings on the under side of the main and upper part of the seating rails. The space between the two rails, is first boarded vertically with tongued and grooved boards and then planked fore-and-aft, to correspond with the outside bulwarks. The seating rail in this case, is a continuation of the sheer at main rail height.

The *berthing rail* is next above running from the bow to the side of the bowsprit, supported and held in place by light iron stantions the same as the rails below; the opening between may be boarded up or covered with canvass. The berthing rail in this case, is a continuation of the sheer at hammock rail height.

The *flooring in the head* is put in at the height of the main-head-rail caulked and covered with lead sheathing; on this the head seats ar

placed; a *scupper* is cut through the flooring and head on either side. [Note.—Refer to Models of "Wabash and Franklin" in Seamanship Room.]

GRIPE.

The *Gripe* is a piece bolted to the fore side of the stem it completes the lower part of the cutwater and runs down according to the shape "laid down for it," falling in fair with the fore-foot or forward end of the keel; the pieces are joined together with plain scarphs.

A composition plate is usually placed on the front of the stem extending from *four* feet under the keel to the cutwater. At the load water line this plate extends back *four* feet on the plank, and is securely fastened that it may be used as a ram. The after edge of the remaining portion extends sufficiently on the stem to be securely fastened to it. The thickness on the front at the load water line is about *one and a half* inches, and the corners are chamfered or rounded.

CAULKING.

The seams of planking, in order to receive the oakum, require to be open to the extent of about one-twentieth of the thickness of the plank. A guage for the proper width of opening is made by setting the arms of a jointed rule to the angle produced by $\frac{1}{2}$ inch of opening between them at a point 10 inches from the joint, when the opening between the arms of the rule at a distance from the joint equal to the thickness of the plank will show the proper width of opening for the seams at their outer edges.

Seams that are closer than the proper width are opened or *reemed* by the *reeming irons* and *beetles*. This is considered also a test of the sufficiency of the fastenings; and should they prove insufficient, so that the planks are started by the opening, new fastenings are at once put in. After each seam has been opened or reemed, the proper number of threads of oakum are forced in one after another by means of the *caulking iron and mallet*. After the oakum has been driven in, it is further compressed by means of a tool called a *horsing-iron* held by one caulker and struck with the beetle by another, this is called *horsing up*. The wales and bottom plank are caulked *solid* and *home to the timbers*; the Gun and Spar decks with not less than *four* threads; the Berth deck with *three* threads; the Bulwarks, Poop and Top-Gallant Forecastle in proper proportion. The seams of the Bulwarks and Poop deck are usually payed with paint and puttied; all all other seams are payed with pitch and scraped clean.

The opening and caulking of one seam tends to close the seams near it; so that although some of them may have been previously above the proper width, they may still require to be opened before caulking.

The opening and caulking of seams require careful superintendence, to see that the seams are really opened to the bottom, and not merely notched into shallow grooves; and that the oakum is actually driven home to the bottom of the seams and not choked or wedged into a mass near the surface, leaving the bottom empty. Butts and scarphs of the keel are caulked like seams; and so are any rents or shakes that may occur in the planking.

In caulking decks and light bulwarks the operation of reeming and horsingup are usually omitted, particularly where soft wood is used. After the vessel is caulked she can be planed off fair and smooth, painted and her bottom covered with copper or yellow metal sheathing.

SHEATHING VESSLS WITH COPPER AND YELLOW METAL.

It was not until the latter end of the last century that copper was introduced for covering the immersed portions of vessels. This coating of copper extends over the whole immersed portion of the vessel. It is formed of sheets 4 feet in length and 14 inches in breadth; the lower edges of the upper sheets lapping over the upper edges of those belowthem, and the after end of each sheet lapping over the fore end of the one immediately following it. They are fastened with mixed-metal nails called sheathing nails; yellow metal called Muntz metal, is generally used in the merchant service, and during the rebellion, in the naval service; it is less expensive when compared with copper.

The copper for sheathing is usually made in sheets of the following weight in ounces per square foot. 18, 22, 24, 26, 28, and 32, but oftener is divided into four thicknesses of 24, 26, 28, and 32, ounces, and is applied in the followtng manner;—[Taking a vessel of the "Brooklyn" class as an example.] The 32 ounce sheathing should cover the bows diagonally from the fore-mast, at lead-line to the fore-foot, and the parts between wind and water; 26 and 28 ounce sheathing the rest of the bottom; the keel is covered with a double thickness of 24 ounce sheathing; 28 or 32 ounce sheathing is placed on the rudder.

To ascertain the quantity of copper required to sheathe a vessel, measure the length of the keel, and find how many sheets it will take to extend the whole length, allowing 3 feet 11 inches for the length of a sheet; then ascertain the number of courses required from the keel to the copper-line, allowing 13 inches for the width of a course, multiply the number of courses by the number of sheets required in the length of the keel, and the product will be the number of sheets required on each side.

To the above amount add 25 per cent for keel, stem, stern-post, rudder and one strake above the lead-line.

A full built ship requires one-twentieth more sheathing metal than a sharp one.

Sheets of sheathing metal are usually punched for three and five rows of nails; the sheets punched for three rows, require 39 nails; those for five rows, called double nailing require 49 nails.

The seams under the copper sheathing are filled up flush by laying in a thread of spun-yarn or oakum and the bottom is sometimes payed with pitch, or tarred paper is put on under the metal.

It is usual to launch a vessel before sheathing her performing the sheathing process afterwards in a dock.

Seventh Lecture.

Subjects:—Mast Steps, Capstans, Directions for working Brown's Patent Capstan, Wooden Rudder, Iron Rudder, Equipoise or Balance Rudders, Steering Wheels, Cat Heads, Boats, Ventilators.

MAST STEPS.

The *Steps* of the fore and main mast in all modern built ships are *cast iron shoes*, fitted over and secured to the main keelson.

The *Mizzen mast* in all vessels steps in the berth deck.

A piece of white or live oak is jogged down below the top of the beams and projects above the top of the deck for a length of three feet, and thence thinned down to the thickness of the deck plank, it is long enough to reach *three* beams, and is bolted edgewise and to the beams. A *tenon* is cut on the heel of the mast and a corresponding *mortise* is cut out of the oak piece to receive it.

CAPSTANS.

Capstans are machines for winding up ropes or chains; it has its axis vertical and is especially suited for being driven by hand power, the men walking or running round it, and pushing before them the capstan bars which radiate from its head. It is well calculated for making available the strength of a numerous crew.

Capstans are distinguished into *single and double*, according as they have one or two barrels upon the same spindle, or vertical axis — The barrel of a single capstan, or the lower barrel of a double capstan is on the deck on which the cables are worked, and is used for heaving in the cables; the upper barrel of a double capstan is on the deck above. In either case the spindle has the framing of two decks to keep it steady; it turns in a bush or collar in the upper of those decks, and has the pivot at its lower end supported by a *step* fixed to the lower of them.

In the model of the "Antietam," the fore-and-aft pieces let down between the beams, forming the *capstan-bed* may be seen; they are of white or live oak, about 8 inches in depth.

The spindle is of tough wrought iron. Its greatest diameter is about the middle, and ranges from 5 to 8 inches. It tapers towards the ends, where its diameter is about $\frac{2}{3}$ of the greatest diameter.— The *upper barrel* is fast on the spindle and turns with it, while the *lower barrel* is loose on the spindle but can be made fast to it when required, so as to turn along with the upper barrel in the following manner:—On the top of the head of the lower barrel is a circular plate; and just above it, fixed to the spindle, a similar circular plate— these are called the *connecting plates*; they have corresponding holes in them, and by putting bolts called *drop bolts* into these holes, the lower barrel is connected with the spindle and made to turn with it.

The *barrel* of a capstan ranges from 16 to 28 inches in diameter, and is usually polygonal with ten or twelve equal sides. From the

alternate sides ribs project, called *whelps* which are frequently five or six in number, and they are of such a breadth that the mean diameter measured over the whelps, is about double the diameter of the barrel.

They are kept apart at their upper and lower ends by chocks.—They taper towards the upper end, so that the diameter over the whelps is 4 or 5 inches less near the upper end than at the lower end; this is called the *surging power*, and its object is to make a rope when wound round the capstan, gradually *surge* or slip from the larger end where it is led on towards the smaller end, where it is led off, in order that the successive turns of the rope may not override each other at the larger end.

The *trundle or drum head* of a capstan ranges from 3 to 5 feet in diameter, being a little greater in diameter than the greatest diameter over the whelps. It has square holes all around its outer rim for inserting the *capstan bars*, at the rate of about one to every foot of its circumference, or nearly so; these *bar holes* are from 3 to 5 inches square, tapering inwards and from 10 to 12 inches deep. The length of the capstan bar is about three times the diameter of the trundle head, or from 8 to 14 feet long. They are fastened in the bar holes by means of small pins dropped in from above, and are connected together all round by a rope through their outer ends, called a *swifter*. The *pauls* or catches, for preventing the capstan from running back are connected to the lower part of the capstan, called the *paul head*, and they drop between and take hold of the teeth of the *paul rim or ratchet*, a cast iron toothed ring which is let down into and bolted to the deck and capstan bed. When required the pauls can be supported clear of the ratchet by means of small pins.

The lower end of the capstan on the lower deck is formed of cast iron, so as to receive the end of the barrel, which is fixed securely into it, it is called a chain lifter, and combines the paul rim with it. Its rim is of the form of a deep groove, with projecting ribs on its upper and lower surfaces; so that the alternate links of a chain may fit into the spaces between the ribs.

The *three upright rollers* are made of cast iron with wrought iron spindles, and are for guiding the chain cable so as to make the chain-lifter lay hold of it.

Just forward of the centre of the capstan is a curved wrought iron bar, called a *chain tripper*, the forward end is securely bolted to the deck, the after end is forked shaped and rests close to the inner edge of the chain lifter; its use is to trip the chain out of the groove should it get jammed and be carried round to that point.

This mode of fitting a capstan, so as to enable it to act directly on a chain cable, is known as *Brown's* fittings. Capstans of this description have been in use on our naval vessels for a long time, but nearly all our modern vessels are furnished with iron capstans, known as *Brown's Patent Capstan* These capstans have an arrangement by which the power is increased as 3 to 1, viz: A cog wheel, in diameter $\frac{1}{3}$ that of the inside of the pall haad, is keyed to the shaft of the capstan, inside the pall head; just below this, there is a triangular shaped

piece of plate iron, which is also secured to the shaft; on the upper side of the plate, and secured at either angle, are three corresponding cog-wheels, which are used to transmit the motion from the centre wheel to the inside of the pall head, which is cast to receive the teeth on the wheels. There are two *slides* in the pall bed which can be *shoved in* to secure the triangular plate and put the wheels in gear, or *pulled out* to disconnect them. The capstan head is keyed to the shaft and is independent of the barrel; when used as an ordinary capstan it is connected to it by two palls on the inside of the capstan head, which can be turned by small cranks from the outside.

DIRECTIONS FOR MAKING BROWN'S PATENT CAPSTAN.

When heaving with the single purchase the *palls* in the *capstan head* are pointed in the *same direction as the men walk*, and the *slides* in the pall bed are pulled out.

To increase the power, *push the slides into* the pall bed and walk the *contrary way*.

WOODEN RUDDERS.

A wooden rudder consists of an assembly of pieces of timber tongued and bolted together like those of the head. [Note] Refer to model of the stern of the "Franklin" in Seamanship Room.]

The forward piece is called the stock, the after piece is called the backing piece; the center pieces are called the filling pieces and are made of pine; the piece on the bottom covering the ends of the filling pieces is called the shoe, and together with the pieces first named is made of oak.

The rudder is generally bearded about to an angle of 38° and the stern post is also bearded about 8° allowing the rudder to swing to an angle of 42°. The pintles are cast with straps to secure them by, which are let into the sides of the rudder and through bolted.

The wooden rudders used at the present time are round-headed or patent rudders. The advantage arising from this form of rudder and mode of hanging it is this, that the hole through the counter or stern of the ship which is called the rudder port, is wholly closed up by the head or plug of the rudder passing though it, with almost a close joint, as the center of the rudder head, whereby the round head of the rudder becomes a large pintle working in the counter or rudder port. The braces are fixed to the after part of the stern post. The braces are fixed to the after part of the stern post to receive the pintles, they are cast with straps which extend on either side of the post and are through bolted to it. Great care is taken in letting on the braces to the post and pintles to the rudder; that they may work with each other as one joint. A metal step called a *saucer* is secured to the stern post below the center brace so that the end of the pintle rest on it keeping the straps of the braces and pintles from coming close together, thus relieving the braces of the weight of the rudder and lessening to great extent the friction which there would otherwise be and allowing it to turn much easier. Two saucers are used in large vessels like the "[illegible]-bash" or Franklin. There is also fitted to the rudder what is

called a *woodlock*, which is a piece of wood placed in the score, cut out of the rudder under the brace which receives the *upper pintle*, and which is generally above the water line; this woodlock is made to have its upper end bearing against the under side of the brace, and the lower end against the score in the rudder; by which means the rudder is prevented from rising or being unhung.

The woodlock is made of oak coppered and secured in place by a copper bolt driven through cornerwise so that it can be readily drifted out when the rudder is required to be unshipped.

The rudder head has wide iron bands shrunk on to it, let in flush, though which the tiller holes are cut. Quadrants made of composition or wrought iron are generally used as shown in the model before you, but are or should be provided with a spare tiller that can be used in case of any accident.

There is also a short composition tiller placed in the back of the rudder just above the water called a *preventer tiller* having composition chains shackeled to it for a short distance the remaining length being made up of rope pendants called *rudder pendants* which are stopped up to small eye bolts around the stern and led to the quarters, where the ends are firmly stopped to eye bolts driven for that purpose, the use of the rudder pendants is, to provide means for stearing the vessel should the rudder head be sprung or carried away. Above the preventer tiller a composition yoke with an eye on either corner, to admit of shackeling a chain to, is put on and finally secured to the rudder; to this yoke two heavy composition chains are shackeled; the upper end shackeled to heavy eye bolts driven in the counter of the vessel directly above; the use of these chains is to hold the rudder and prevent its loss should it be carried away or unshipped from any cause.

The rudder is sheathed with heavy copper; a hole is cut near the heel and lined with lead, large enough to reeve the heel rope through in shipping it; a large eye bolt is temporarily placed in the rudder head, forelocked in the tiller hole; for the purpose of hooking the top-pendant, to hoist it up through the rudder post; a bolt is placed through a beam or carling directly over the rudder post and forelocked above, to hook the top block to.

IRON RUDDER.

The main piece or front of the rudder is almost invariably, a solid forging, the pintles being forged in one with it, and in most cases the back of the rudder is also formed by a solid iron frame which is welded to the main piece. In some cases, however, the body of the rudder has been made of a single plate, and the rudder head and pintles have been separately forged and riveted to the plate rudder.

The rudder of a large iron ship is now usually made in the following manner:—The main piece is made in one forging from the head to the heel, lugs in the rough being brought on to receive the other portions of the frame. The forging of the main piece is so formed as to admit of the pintles being worked out of the solid, and they are

afterwards shaped out under a slotting machine and completed by hand with chisel and file.

A turning machine has been sometimes used for the purpose of finishing the pintles, and machinery may be advantageously employed also for boring the holes in the braces and taking out the gulleting in the back of the rudder post. The back of the rudder is formed in a separate forging, and is connected with the main piece by horizontal stays The stays and back of the rudder are welded to the main piece by means of the stays left on it for that purpose, and thus the rudder frame is made into one solid forging. The back and heel of the rudder are usually tapered considerably from the dimensions of the head, and the sides are made nearly in one plane, and covered with plating worked flush

The front, back, and stays of the rudder frame are perforated through and through with holes for the riveting of the side plates and the edges of the plates are connected by internal edge strips worked between the stays. After account has been taken of the rivet holes in the rudder frame, and the edge strips have been fitted in place and the holes for the edge riveting punched, the plating of each side is taken off, the holes for the fastenings in the rudder frame are drilled, and the edge rivets are put in. When this work has been completed, the plating is replaced on the frame, and the through riveting is proceeded with. The edges of the plating are caulked in the ordinary manner, and the whole is supposed to be perfectly water-tight. There is, however, a difficulty in insuring this at first, and when it is remembered that the rudder is very liable to be struck, it will appear that the chances are greatly against the inside of the rudder being free from water. With a view to ensure the exclusion of the water, rudders are frequently filled in between the frames and stays with some light wood and then covered by the side-plates in the usual way. The diagram on the black-board illustrates the preceding description.

Between the front and back of the rudder there are four horizontal stays, marked *s*, and upon the upper and lower stays stop-cleats, marked *c*, are riveted, and serve to prevent the rudder from being put over past a certain angle, or being driven beyond it by a sudden blow. The number of cross-stays similar to *s* varies with the size of the rudder, and in vessels of moderate dimensions they are entirely dispensed with. In very small vessels the back piece also is omitted, and the plates are secured to the main piece, their after ends being brought together and riveted. It will be noticed that the pintles are forged in one with the main piece, and that their centre is in a line with the centre of the rudder head, as is usually the case in iron rudders. The pintle at the heel fits into a socket in the after end of the keel piece, and the other pintles fit the braces forged on the rudder post. The pintle next below the upper one and that next above the lower one are considerably shorter than the other pintles, and they have steel pins screwed into their lower convex surface. These steel pointed pintles bear on corresponding steel pins fitted in the braces, when the rudder is in place, and the weight of the rudder being taken by these convex surfaces

of steel, the friction is reduced to a very small amount, and the rudder is made to turn readily. The importance of this arrangement will appear when it is considered that the total weight of a frigate's rudder made in this way is about 15 tons, of which weight the frame makes up 12 tons and the plating, fillings, &c., the remaining 3 tons.

EQUIPOISE OR BALANCE RUDDERS.

Equipoise or Balance Rudders have within the last few years been more frequently employed, both on ships with single and twin screw propellers. This adoption of balanced rudders has been consequent on the recognition of the great advantage they possess as compared with ordinary rudders in respect both of the increased area of rudder surface thus obtainable, and the ease with which they can be put over to very large angles. Of the total area of the rudder one-third is before the axis and two-thirds abaft it.

As instances of single screw ships with balanced rudders, we may refer to the "Antietam," and "Congress," (wooden vessels,) monitors "Passaic and Dictator," (iron vessels). As examples of twin screw ships with balanced rudders, we may mention the light draugh monitors, (iron vessels). In iron vessels the keel is prolonged for a few feet abaft the stern post having a socket worked in it to receive the pintle in the heel of the rudder. The rudder head passes up through a stuffing box arrangement fitted to prevent the passage of the water inboard. The weight of the rudder is taken inboard, the pintle at the heel only being intended to steady it. A circular casting is secured to the deck around the rudder head and forms a table, upon the upper bevelled surface of which the friction rollers rest. These rollers are of brass and are conical frusta in shape, being secured in the cone band P as shown in the diagram on the blackboard. The rudder head is of uniform diameter as far up as the upper side of the cone band, but from that point, and throughout the depth of the forging S, the diameter is reduced, forming a shoulder of $\frac{1}{2}$ inch at the upper and lower edges of S. By means of this shoulder all the weight of the rudder is transmitted by S, is formed in such a manner as to overlap the fore edge of the locking plate, and the locking pin used to keep the rudder fixed is shown. For iron vessels these rudders have a frame of wrought iron plated over and filled in with light wood; for wooden vessels, they are made of composition with an iron head;—no frame is required as it is cast in a mould around an iron shaft, the sheel of the rudder is about $\frac{7}{8}$ of an inch in thickness. Several holes are left open on one side in casting it, in order that the *core* may be taken out, they are afterwards closed with composition screw plugs. The heel of the rudder rests in a composition casting or shoe secured to the stern post and together with the rudder is generally provided and fitted by the contractors for the steam machinery.

A long ship requires a broad rudder. For every 100 feet in length of the ship, she wants *two* feet breadth of rudder, and *one* more added, thus, 100 feet long will require a *three* feet rudder; 200 feet long, a *five* feet rudder; 300 feet long, a *seven* feet rudder.

STEERING WHEELS.

Steering wheels range from 3 to 6 feet in diameter, the barrel rim and standards of the wheel are made of mahogany, the spokes of locust, the shaft is of copper or composition with *patent roller bushings*.

The rudder is so connected with the steering wheel in every case, that in putting the helm over, the lower rim of the wheel shall be moved in the opposite direction to the rudder, that is, in the same direction with a tiller pointing forward.

Hence, when the tiller points forward, the wheel ropes pass over the barrel first, and when it points aft, under the barrel.

The arrangement of the wheel, wheel ropes and tiller, is shown in Fig. 97, Text book

The method usually adopted for getting rid of slack rope, is to make the diameter of the barrel smaller at the middle than at the ends, so that in moving the rudder from amidships to the extreme position, the excess of rope wound on the barrel over that unwound is equal to the rope which would have been slack had the form of the barrel been cylindrical.

The use of a quadrant becomes necessary in vessels of the "Wabash, Juniata and Iroquois" classes, which have a lifting screw, on account of the propeller well occupying the place where the tiller would move.

CAT HEADS.

Cat Heads are usually made of a pair of white or live oak knees, one projecting on each bow, with stive or upward slope enough to allow the anchor to lay level when stowed, and of a sufficient length to insure that the anchors shall hang from them clear of the ship's side. The projecting part of each cat head is supported by a knee called the *cat-head supporter* bolted to the cat head and to the ship's side. The inner end of each cat head generally runs down inside the ship's side through which it is bolted. A wide wrought iron band is usually let in flush on the top of the inboard portion of the cat head, running a short distance on the outboard portion, to add to its strength, and the bolts which secure it to the vessel's side are driven from the outside and clinched in countersinks on this plate. The outer end of the cat head is hooped to prevent its splitting, and has usually three mortises in it for the sheaves of the cat fall. The end is finished off with a carved cat's face or a star. Cat heads are sometimes of solid forged iron, and sometimes built of angle irons and plates. Cat heads are fitted with a cast iron cleat called a *thumb cleat* secured to the after side and a tripper on top, on the forward side for the cat stopper, also an iron belaying cleat on the top-gallant forecastle deck. When the anchor is stowed, the inner fluke rests on an iron covered board, called the *bill board* which projects from the side with a slight outward slope, The bill boards are fitted with *trippers* and iron belaying cleats for the shank painters. Ring bolts are also placed where required, to lash the anchors when stowed for sea.

BOATS.

Boats are distinguished as *Carvel built* and *Clincker built*, according to the manner of building them.

In both of these styles of boat building, there is a keel, stem and stern post, rabbetted to receive the planking, as in a ship; the stem is scarphed, and the stern post tenoned to the keel.

Carvel built boats are built like ships in miniature. They have frames, each generally consisting of a floor and two futtocks; the floors are scored down over the keel and fastened to it with bolts in the larger and nails in the smaller boats The frames are sided, moulded and trimmed to their proper bevellings, like those of a ship, and are kept temporarily in their shapes and places by cross spawls, ribbands, harpins and shores. The planking consists of strakes laid fore-and-aft with flush seams, like those of a ship, they are usually fastened with two nails in each timber of the frame, driven through and clinched on small rings called *burs*. The strakes first put on are the lowest, or *garboard strakes*, and the uppermost but two, called the *binding strake*. Above the binding strake is the landing strake; the gunwale rests on the timber heads, and covers the upper edge of the landing strake, and the uppermost or *sheer strake*, has its upper edge flush with the top of the gunwale, and its lower edge overlapping the landing strake. The stem is usually strengthened by a *transom*, and the bow by two *hooks*. Strakes above the gunwale are called *wash-strakes*.

The *thwarts* are the transverse planks which keep the sides asunder, like the beams of a ship, and serve as seats for the rowers; some are fixed, and others loose; the fixed thwarts are secured to the sides with knees. The thwarts are spaced about 2 feet 10 inches, from centre to centre, in single banked boats, and 3 feet in double banked boats.

Some boats have a fixed inside planking or *ceiling*, in the bottom; others have moveable *bottom boards*; others *gratings*.

Clinker-built boats are the lightest class for their strength and size; they are distinguished by the lower edge of each strake of plank overlapping the upper edge of the next strake below. They are not built upon frames, but upon temporary transverse sectional moulds, two, three or four in number, which are fixed at their proper stations on the keel; the strakes are then put on, beginning with the garboard strake; and bent to the figure given by the moulds; each strake is fastened to the next below it by nails driven from the outside through the *lands* or overlaps, and clinched on burs on the inside.

When two or more lengths of plank occur in a strake, they are scarfed to each other, the outside lip of each scarph pointing aft.—The scarfs have a layer of tarred paper between, and are fastened with nails driven from the thin end of each piece. Towards the hooding-ends, the strakes are chased into each other; that is to say, a gradually deepening rabbet is taken out of each edge at the lands, so that the projection of each strake beyond the next below it gradually diminishes, and they all fit flush with each other into the rabbets of the stem and stern posts. Floors, futtocks and hooks are afterwards put in, and fastened to the planking by nails driven from the outside, and clenched on burs on the inside of the frame. The keel, stem, stern post and frames of boats are usually made of oak; they are planked with cedar, cypress and juniper boards, excepting the launches which are planked with oak.

Carvel built boats are laid off on a floor, the same as in ship building, moulds made and bevellings taken for the timbers.

All boats bottoms are copper fastened, and the bands which run down the front of the stem and on the after part of the stern post are made of copper.

Launches and 1st Cutters for Frigates and 1st class Sloops of War, and Launches for 2nd, 3rd and 4th class Sloops, are fitted without knees; the clamps being made sufficiently strong for the bolts in the athwart to pass through them and forelock. The ends of the athwarts are fitted with iron plates through which the bolt that holds them passes. All Launches are sheathed with copper

All bolts have two ring bolts through their stem and stern posts; the lower bolt is from nine to twelve inches below the upper one, with an oblong link, which is of the same height as the upper one when both are turned up.

All Launches are fitted with a stout copper ring bolt, one-fifth from each end, and another amidships down through the keel, and well clinched on the lower side of keel.

Launches are fitted with rollers forward and aft, of sufficient length to take the ship's chain.

All boats except Gigs are fitted with copper pipes or well amidships. Launches are fitted with windlasses for weighing anchors.—

The head sheets of Cutters and Whale Boats are not laid with the sheer of the boat, but are slightly depressed towards the stem. All Whale Boats are lap-streaked or clinker built.

Launches and 1st Cutters of vessels which are allowed boat guns are properly fitted for them, and rigged Cutter fashion. The other boats of large size are rigged Lug fashion, and the smaller boats with sprit sails. The fixtures required in boats for boat guns, are two eye bolts on each bow to receive the hooks of the skid; two cross pieces of yellow pine to bear the carriage, so as to carry the muzzle of the howitzer just above and clear of the gunwale and stem.

One piece of yellow pine scantling, placed lengthwise and amidship mortised into the rear cross-piece to sustain the carriage in sweeping. The following moveable pieces are required, viz: six pivot plates and bolts—one at the stem, one at the stern, one at each bow, and one on each quarter; two light wooden tracks to lay along the thwarts for the wheels of the field carriages and slide of boat carriage; one midship wheel track for the trail of field carriage; two stout skids, each fitted at one end with two hooks, and connected at the shore end by an iron brace.

The chocks with rollers at the stem and stern posts of launches are arranged to be removed when the gun is used.

VENTILATORS.

Ventilation pipes made of galvanized iron are fitted in all screw steamers; one aft leading from the shaft passage to the upper deck; the portion of the pipe above the berth deck is divided in the centre and is made to answer as a ventilator for the after part of the ward-room. The one forward leads from the berth deck to the top-gallant forecastle. The portion of the ventilators which comes above the poop deck or top-gallant forecastle are made of copper or galvanized iron, and have large bell mouthed hoods, which are faced to windward at pleasure.

Eighth Lecture.

Subjects:—Internal arrangements of the "Antietam," Construction and fittings of Magazines and Shell Rooms, Gun tackle bolts, Spaces required for working guns, Truck carriages and Pivot carriages, Sizes of Socket and Pivot bolts, Position of Gun tackle bolts for Broadside guns, Fife Rails, Fore and Main Sheet Chocks, Fore and Main Tack bolts, Topsail Sheets, Bolts for Jib and Topmast Staysail Sheets, Bolts for Fore and Main Spencer and Spanker Sheets, Bolts for Leaders for Topsail Halliards, Boomkins for Main brace, Fore and Main Stay bolts, Bolts for Top tackles and Leaders for Top Tackles, Bolts for Leaders for Fore Stay Tackle Fall, Bolts for Main Yard and Main Stay tackle Fall, Miscellaneous Bolts and fittings required to complete the Vessel, Launching, On completing the Launching of Ships which have stopped on their Launching Ways.

INTERNAL ARRANGEMENTS.

The following will give a general idea of the Internal Arrangements of a screw corvette, such as the "Antietam" and class.

The hold and decks are first subdivided off into compartments by bulkheads.

Commencing forward in the *hold* there is a *water tight bulkhead* about fifteen feet from the bow, running up to the underside of berth-deck beams. Next abaft this is the *fore peak*, thirty feet in length, appropriated to the storage of boatswain's, carpenter's and other stores. Next abaft this is the *forward magazine* for the storage of a portion of the powder. The after bulkhead of the magazine is also the forward bulkhead of the fore hold.

[A detailed description of the construction of the magazines and shell rooms is given in this lecture]

From this bulkhead to the after one of the fore hold is a length of about 33 feet, against the after bulkhead are stowed six *water tanks* holding about 1200 gallons each, and made to stow in two tiers, side and side, athwartship. The two after midship tanks are called receiving tanks, and receive the water fresh from the condenser. All ships are now furnished with an apparatus for aerating the condensed water. A portion of the ship's provisions are stowed in the fore hold. The fore-mast steps in an iron shoe just abaft the magazine in the fore hold.

Abaft the fore hold, a space thirteen feet fore-and-aft, and the entire breadth of the hold at that part, is occupied by the chain-lockers for the bower and stream chains in the centre, and a *shell room* in either wing. (The construction of the latter are explained further on.) Immediately abaft this is the forward or main coal bunker, which communicates directly to the side bunkers, the whole space occupied by the coal enclosing the space occupied by

the engines and boilers, and to a certain extent protecting them from shot in action. The coal in the side and main bunkers stows as high as the berth deck. Inside of the iron bulkheads, forming the coal bunkers are first, the *four main* and *one donky boilers*, and next the *engines*. The whole space occupied by engines, boilers and coal is one hundred and fifteen feet. The heel of the main-mast steps in a cast iron shoe, secured to the keelsons, between the boiler and engine space. As far aft as the shaft box is a space enclosing the shaft, formed in this case by a bulkhead running up to the under side of the orlop deck, and known as the *shaft alley;* the bulkhead on the starboard side is close to the shaft bearings, on the port side there is a passage way about two feet in width clear of the shaft.

Abaft the after bulkhead of the engine-room is the after-hold, occupying a length of about fifteen feet on either side of the shaft alley and used to stow dry provisions. Next, the *after magazine* on the starboard side, and the *after shell room* on the port side of the shaft alley, occupying a space of about sixteen feet in length.—Abaft the magazine is a store room for *boat ammunition*. The remaining space is devoted to small *store rooms*. The beds or bearings built up over the main and sister keelsons to support the line of shafting, are known as the *thrust bearing, bearing blocks* and *pillow blocks*. The thrust bearing is next to the shaft box, there are two pillow blocks, one just abaft the connection of the main and crank shafts, and one midway between that and the thrust bearing; the bearing blocks are placed in the intermediate spaces. In all cases the location of them is determined by the steam engineers.

FORWARD ORLOP DECK.

This vessel has not a regular orlop deck, framed and kneed as is the case in vessels like the "Wabash," but has a light deck below the berth deck which answers the same purpose.

The *forward orlop deck* is in length about fifty-two and a half feet, and is divided off commencing from forward as follows:—The first space bulkheaded off is known as the *general store room or yeoman's store room*. Next, the forward bread rooms. *Bread rooms* are first lined with tongued and grooved stuff, and then with sheet tin; wooden gratings are placed on the floor over the tin, and shifting boards fitted to the doors in order that the bread may be stowed properly when carried in bags; extending to the forward bulkhead of the fore hold. On either side of this deck, aft, a bulkhead is run up enclosing a space, which is entered from the deck above, making a passage to the light box on the port side, and a passage to the magazine on the starboard side. Over the shell rooms in the fore hold are situated the sail rooms, having a passage through them to the shell rooms.

The *after orlop deck* extends about sixty feet abaft the after bulkhead of the engine room. The forward and after bulkheads of the after magazine, shell rooms and hold, are run up to the under side of the berth deck beams. The space enclosed on the orlop deck is divided as follows: Two store rooms about six feet square, are

located directly in the centre. On either side of them, is a passage way about four feet wide, and in the wings on either side, are two store rooms; access is had to the after hold, store rooms on either side, and to the light boxes of the magazine and shell rooms through this passage. Abaft these store rooms are the *after bread rooms*, extending the whole breadth of the deck with a bulkhead in the centre between them; entered from the deck above. Next comes the *passage* to the shell room, on port side, and to magazine, gunner's store room and boat ammunition room on the starboard side.

The bulkhead forming the shaft-alley abaft the passages last named runs up to the berth deck: on either side a light deck is put inside of them about eight feet below the berth deck and divided off into *four store rooms* for mess and other stores; with a passage way for the purpose of gaining access to the store rooms in the hold below.

BERTH DECK.

Commencing forward on the berth deck, the first portion bulkheaded off is the *sick bay;* then the *forward berth deck* appropriated to the crew, fitted with *bag racks, hammock hooks, swinging tables, seats* and *mess chests.* A bulkhead with sliding sashes or windows, made to lower into a pocket on the inside, enclose the fire and engine room hatches with an entrance to each from this deck. It was first intended to put a coal bunker abreast of the fire and engine room hatches, extending further forward, on this deck, but that idea has since been abandoned. Next comes the *dispensary, engineers mess store room,* and *warrant officers mess store room* on the port side: *Paymaster's issuing room, marine clothing,* and *steerage mess store room* on starboard side. Next comes the *state rooms* of the warrant officers, boatswain, gunner, carpenter and sailmaker, the first two on the starboard side, the others on the port side; abaft which are the starboard and port steerages, occupied by the midshipmen and assistant engineers; finally the ward room bulkhead abaft which are six state rooms [this is as first designed, but will have to be altered; under the present regulations a larger number of state rooms will be required,] on each side with pantry abaft, appropriate to the use of the commissioned officers. The cabin store room is abaft the ward room pantry, but is entered through a hatch in the cabin on gun deck.

MAIN OR GUN DECK.

This deck has no bulkheads, except those surrounding the engine room and the cabin bulkheads aft. Commencing forward, first is the *manger, heel of bowsprit bitts, water closets* for officers and crew on either side, two pairs of cast iron *mooring bitts,* (bower and sheet) *controllers* to each, abaft the manger board, and one directly over the chain locker abreast of the forward main deck capstan; *galley,* just abaft the foremast. There is one pair of *bilge pumps* located directly forward of the fire room hatch and one pair forward of the hatch to the after hold; finally, the *main deck cabin bulkhead,* abaft

which are two ordinary sized state rooms and a bath room on the starboard side, and a large state room and water closet on the port side, with the cabin pantry on the port side and armory on the starboard side forward of the cabin bulkhead. A pair of *towing bitts* are located abaft the mizzen mast on this deck. Shot racks for solid shot and empty shell are put around most of the hatches on this deck. *Hammock hooks* are put in the spar deck beams that a portion of the crew may swing on this deck.

SPAR DECK.

Commencing forward, first is the bowsprit step, two water closets on either side, capstan directly over the one on main deck, after capstan forward of steerage hatch; forward of the fore hatch, are tracks and pivot bolt sockets for a pivot gun; finally, directly abaft the main deck cabin skylight, is the *poop cabin* bulkhead, abaft which, there is a *state room, water closet and pantry*, on the port side, and a *bath room, state room and office* on the starboard side. Topsail sheet bitts are placed forward of the fore, main and mizzen masts; *fife rails* and leading blocks around the fore and main, and a brass pin band on the mizzen, the leading blocks at the mizzen secured to a brass *hawse rail* fixed to the mast combing.

MAGAZINES.

No detail of internal arrangement should be more carefully considered and executed than those relating to the stowage and delivery of powder, since a defect in these particulars, apparently insignificant, may lead to the instantaneous destruction of the ship or with the incendiary and explosive projectiles now used, to her becoming, comparatively an easy prey to an antagonist. In view of the fact that all the powder for great guns is now put up in *cubical copper tanks*, made water tight, the form of magazines should be as nearly rectangular as the shape of the vessel will admit, and they should be built strong enough to resist sufficiently the effect of her working in heavy weather, and also the pressure of water they will have to sustain in case of being flooded.

All magazines should have a *light box* for each alley at one end, and a *passage* to delixer powder at the other; and the magazine and its passage considered as one, must be made perfectly tight by caulking the (three-inch pine) bulkheads and flooring, and then lining them internally, first with white pine boards, tongued and grooved, battened off one inch from the bulkheads, sides rnd flooring, and again with sheet lead of 6 pounds to the square foot on the sides and bulkheads, and 8 pounds to the square foot on the flooring, soldered together over these boards. Both these linings are to extend entirely over the bottom or floor, and all the way up to the deck above on all the sides.—The athwartship bulkheads are lined externally with sheet iron as a protection against fire, and to prevent the intrusion of rats. A magazine aft in a ship has its passage for delivering powder adjoining its *forward part;* and one forward in a ship has this passage adjoining its *after part*, in order that it may not be necessary to pass the powder

over the light box scuttle. The bulkhead between the passage and magazine room is put in after the magazine is lined, it is generally white pine tongued and grooved plank, two and a half inches in thickness. As many doors are cut in the bulkhead separating this passage from the magazine room as there are alleys to be left in the latter, between the racks or shelves on which the tanks are stowed, and these doors must correspond with the alleys. They are not only to afford a means of entrance to the magazine room, but also for passing the tanks in and out. Through the upper part of each door a small scuttle is cut, for the purpose of passing the cartridges out of the magazine room with the door itself closed; and is to have a lid so arranged as to open outward only, and to close of itself when the scuttle is not actually in use.

Sailing frigates should have two alleys for each magazine. In screw vessels of large class, where the shaft will interfere with this arrangement, two alleys for the forward magazine. In smaller vessels one alley will suffice. In all cases the alley is not to be less than two feet ten inches in breadth, and it ought to be more if practicable, to prevent confusion and delay. Each alley is to be illuminated by a separate light. If there is room in the magazine, there should be space left, at the end nearest the light, for a man to pass from one alley to the other without going into the passage.

Ships with two magazines—one forward and the other aft, should have them as nearly equal, in point of capacity, as the shape of the vessel and other circumstances will admit.

Magazines are constructed as low down as possible. Their floors never come below the tops of the keelsons, but may rest on them — Their height should be equal, only to an exact number of times the height of a powder tank when lying on its side, in addition to the thickness of the shelving. An additional inch for each shelf should be allowed for spring or play. The whole height in the clear should be limited by the condition that a man standing on the floor may reach the upper tier of tanks with ease. Four tiers of 200 lb. tanks, three of them resting on shelves two inches thick, and the other on inch battens on the magazine floor, will with an allowance of one and a half inches for spring and play, require a height in the clear, of six feet two inches. Three tiers will require a height, in the clear, of about four feet eight inches.

A magazine should be placed if possible so as not to include a part of a mast.

All the metalic fixtures about a magazine, delivering passages and light rooms, must be of copper.

Each delivering passage has, for the distribution of powder, at least as many passing scuttles communicating with the orlop or berth deck as there are chains of scuttles above.

Each magazine, as a whole, that is, including the delivering passage being made as stated above, water tight, is to be provided with an independent cock for filling it rapidly with water; a *waste pipe* through the bulkhead at the height of the upper tier of tanks to carry off the superfluous water; and a *valve* in the floor for letting the water off when the magazine is to be emptied after being flooded. Both cocks are

turned from the deck above, each having a lever to its spindle for the purpose, which comes up inside a deck plate, the flange of which is distinctly marked, what it is, the wrenches for turning them are kept in lockers built for that purpose, near each cock, locked and the keys kept with those of the magazine.

LIGHTING THE MAGAZINE.

The magazine is lighted by means of one *regulation lamp*, to correspond with each alley of the magazine room, placed in a light box arranged for that purpose. This box of which a portion of the magazine bulkhead forms a part, is lined internally, with soldered sheets of copper, and has a few inches of water in it whenever the lamp is lighted. The entrance to it is through a scuttle in the deck large enough to admit the lamp generally 15½ inches athwartships, 11½ inches fore and aft, and 28 inches deep, (measured on the inside.) In the portion of the magazine bulkhead just alluded to, and so as to throw as much light as possible into the mogazine room, an opening 12 inches in diameter and 8 inches above the bottom of the light box is cut, which is covered by two plain glasses of about two inches in thickness, somewhat separated from each other, one of which, that next to the lamp, must be permanently fixed in the bulkhead, and the other, or that next to the magazine, is let into a wooden frame, so that it may be easily removed, and thus both glasses cleaned at any time with convenience and safety. The glasses are held in place by a rim of copper fastened with brass screws, after being closely fitted and having their edges made perfectly tight. On the back and sides of the light box inside, there is an inner lining commencing five inches below the top where it is connected to the water tight lining, and extending to within three inches of the bottom, having an off set of three-fourths of an inch; holes for the admission of air to form a draught for the lamp are cut through the back and sides of the box, below the top of the inner lining, covered with copper wire gauze on the outside of the box. A small dome or reversed funnel of copper, is placed above the lamp and fitted with a pipe of the same metal to convey the smoke off. This pipe is made to screw into the cover of the light box, when in use, or, to be reversed and screwed on the inside, and the hole closed by a metal screw plug, when not in use. The dome or funnel is fixed to the light box cover.

Ledges are placed upon the shelves and cleats between each tank to secure them from getting out of place when the ship rolls.

SHELL ROOMS.

Shell rooms are lined internally the same as magazines, and the provision for lighting and flooding are similar. Each room has one light box, arranged like those for magazines.

EXTERIOR DIMENSIONS, IN INCHES, FOR SHELL BOXES.

For XV inch shell,	18	×	18	by	20	high.
For XI inch shell,	12,75	×	12.75	"	14.5	high.
For X inch shell,	11.65	×	11.65	"	13.9	high.
For IX inch shell,	10.63	×	10.63	"	12.9	high.
For VIII inch shell,	10.20	×	10.10	"	12.2	high.
For 32-pounder shell,	8.50	×	8.50	"	10.2	high.

AREAS OCCUPIED BY ONE TIER OF SHELL BOXES.

XI inch.			X inch.			IX inch.			VIII inch.			32 Pounder.		
No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.	No.	Ft.	In.
72	15.5½	× 5.8½	75	15.2	× 5.3½	102	15.8¼	× 5.9¼	108	16	× 6	176	16	× 6
52	14.4	× 4.6½	56	14.2	× 4.1½	80	14.9¼	× 4.9½	85	15	× 5	140	15	× 5

POWDER TANKS.

Capacity of Tank for Powder in grain,	EXTERIOR DIMENSIONS.		Weight when empty.	Approximate weight when filled with Cylinders.
	Height in inches including Lid and Handle.	Sides, in inches.		
200 pounds.	22¼	16½ × 16½	67½ pounds.	218 pounds.
150 pounds.	22⅛	15 × 15	59½ pounds.	170 to 180 pounds.
100 pounds.	20½	13 × 13	.....	.....
50 pounds.	16¾	10¼ × 10¼	.....	.....

DIMENSIONS OF BOXES FOR BOAT AMMUNITION.

Calibre of Boat Howitzer.	Kind of Projectile	No. of Projectiles box contains.	Dimensions of Boxes, in inches.	Weight in Powder.	
				Empty	Filled.
24 pounder.....	Shrapnel.....	9.....	22 × 20.75 by 13.75 high.....	35⅓.....	270⅓.....
24 "	Canister.....	9.....	22 × 20.75 by 15.50 "	36⅓.....	217 .....
12 " heavy.....	Shrapnel.....	9.....	18.75 × 17.75 by 11.13 "	22⅞.....	140½.....
12 " heavy.....	Canister.....	9.....	18.75 × 17.75 by 12.25 "	25½.....	114¾ .....

GUN TACKLE BOLTS.

To all the *gun ports* on covered gun decks the following bolts are required:—two pairs of *breeching bolts* on either side; two eye bolts for *train tackles* one on either side, made with a double eye and flattened on the lower side that a *nib hooked block* may be used; two side tackles or *securing bolts*, one on either side above the breeching bolts and near the sides of the ports; one eye bolt or hook over the centre of each port about five inches below the spar deck beams for housing the gun and for shifting it on the carriage; opposite to each port in the deck there will be one *train tackle* eye bolt, without there is some other bolt already put in that will answer the purpose. For dismounting guns on covered decks, a composition *deck plate* with a metal screw plug, is inserted in the deck above, through this deck plate a heavy eye bolt is placed secured above with a nut or key and iron washer, into this eye is hooked the *breech purchase block*.

The hole or plate through which this bolt is put is directly over the *eas cabel block* when the muzzle of the gun is under the housing bolt; it is afterwards stopped with a metal screw plug.

Spaces required for working Guns on Truck Carriages.

(With muzzle 18 *in.* inside of centre of Port.)

		Ft.	In.		Ft.	In.
IX inch shell,	length of gun & carriage,	11	0	radius	13	0
8 inch of 93 cwt.		10	0	"	11	10
8 inch of 63 "	(old)	9	9½	"	11	10
8 inch of 55 "		9	6	"	11	6
100 pounder Parrott Rifle		13	5	"	15	8
60 " " "		10	4½	"	12	0
30 " " "		9	4½	"	11	6
20 " " "		8	2	"	9	10
50 " Dahlgren "		9	4½	"	11	6
32 " of 57 cwt.		10	5½	"	12	6
33 " " 51 "		10	1	"	12	0
32 " " 42 "		9	0½	"	11	0
32 " " 32 "		7	7	"	9	6
32 " " 27 "		6	10	"	9	0

Space required for working different Classes of Guns on Pivot Carriages.

	Distance of pivot centre from waterway.	Radius. Ft.	In
150 pounder Parrott Rifle	45 inches	14	10
100 " " "	45 "	13	3
60 " " "	38 "	12	3
30 " " "	38 "	11	0
20 " " "	27 "	9	9
XI in. shell, (iron carriage and slide)	pivot at waterway	18	0
XI in, "	45 "	14	10
X in. "	45 "	13	6
IX in. "	45 "	12	0
20 pounder Rifle, or			
24 " Smooth bore,	24 "	7	0

The distance between *pivot centres* of all XI in., X in., IX in , and 100 pdr. carriages shall be either 142 or 117¾ inches, depending on the breadth of beam, position of hatches and other obstructions, and is not deviated from except by explicit direction from the Bureau of Ordnance. For a 60 pdr. Parrott, 130 inches between centres, and for the 30 pdr., 120 inches.

SIZES OF SOCKETS AND PIVOT BOLTS.

	For XI in., X in., IX in , & 100 pdr.	For 60, 30 & 20 pdr.
Length of bolt under the head,	18 inches.	14 inches
Diameter of bolt	4	3
" hole in socket	4 1	3 1
" boss	10 5	8
Height of boss	1 5	1 1

Slot in the pivot-plate one-sixteenth larger than the boss.

For XI in., X in., IX in., and 100 pdr. carriages, the fighting and shifting sockets are bossed, the housing socket plain.

For 60 pdr., 30 pdr., and 20 pdr. carriages, the shifting socket alone is bossed.

Position of Gun tackle bolts for Broadside Guns.

	20 and 24 inch. Port sills. Inches.	16 and 18 inch. Port sills. Inches.
Height of centre of lower breeching bolt from deck.....	14.75	10.75
Distance between upper and lower breeching bolts.....	3.75	3.75
Distance of centre of 1st set of breeching bolts from side port	14.	14.
Distance of centre of 2d set of breeching bolts from side of port	22.	22
Distance of centre of training bolt from side of port.....	36.	36.
Height of training bolt from deck..	21.	14 & 16
Height of securing bolt (side tackle bolt) above port sill.....	8.	8.

For IX inch guns, the *port sill* should not be less than 20 inches in height, and no port sill less than 16 inches, otherwise the carriages will not give sufficient elevation.

FIFE RAILS.

A *fife rail* is placed around the fore and main masts for the purpose of belaying a portion of the rigging, the remaining portion, that is worked from the deck, belays to the pin rails which are secured to the inside of the bulwarks, and should be in length, the space occupied by the spread of the rigging. Between the stantions which support the fife rail, there is an iron rod called a *hawse rail*, on which the leading blocks are secured. Several vessels have been fitted with iron strapped leading blocks fitted to turn on a pivot between two hawse rails, a model of which can be seen in the Seamanship Room. The stantions to the fife rails are also

sheaved for leaders. Under the pin-rails at the side an eye-bolt should be driven in the upper strake of spirketting opposite the space between every two pins, for the purpose of securing *leading blocks* for the running rigging.

Instead of a fife rail a composition *pin band* hinged on the fore side and set up with a bolt and nut abaft, is placed on the mizzen mast. The leading blocks around the mizzen mast are secured on a circular brass hawse rail which is secured to the top of the mast combing.

FORE AND MAIN SHEET CHOCKS.

Fore and Main Sheet Chocks are fixed blocks, made of lignumvitæ placed in the bulwarks of the vessel for the purpose of leading the hauling part of the sheets on deck, in some instances they are placed in the gun deck batteries but oftener in the spar deck; the chocks both inside and out, are fair with the outer surface of the planking, they are put in, in two halves lapping upon the timber to the thickness of the planking two-thirds of its breadth, two bolts being driven through the laps and timber, and clinched on the inside lap. These chocks should be placed in the opening of the frame. The fore sheet chock has, in general, two sheaves, the upper one for the sheet, cut with the proper rake; the lower one for the after guy of the swinging boom. The main sheet chock has only a single sheave. The fore and main sheets are either belayed to large horn cleats secured to the inside batteries, or if convenient, to a large *cavil* placed in the end of the pin-rail. A heavy eye-bolt is placed outside below the sheet chocks for the standing part of the fore and main sheets. An additional bolt is placed below the fore sheet chock for the standing part of the after guy of swinging boom.

Main tack bolts are placed in the waterways, one for the standing part, and one for the leader, they go through and are clinched on plates on the outside planking.

The *Fore tack* if not led to a bumbkin forward, has bolts put in for it on the top-gallant forecastle deck, properly secured.

The *Sheet chocks* and bolts for *tacks* should be properly placed, so that when the tacks are down and the sheets home, the canvass may present as flat a surface as possible to the wind. Therefore, that they may be placed in the best position for the tacks and sheets, mark on the deck plan the point where the foot of the fore course will cut the foremost shroud, and through this point draw a line making an angle with the keel of the ship of 25°; upon this line set off the breadth of the foot of the foresail, which will determine the outer end of the bumbkin, to which the fore tack is brought.

In fixing the place for the fore sheet chock, the same care should be taken; for, when it is brought home to the side, the part of the sail from the after shroud to the after leech will become a "*back sail*." As regards the position of the main tack bolts, the same course must be pursued in determining the place for hauling it down, except that the angle of the yard with a fore and aft line, should not be more than 20°, as the mainsail should always be braced sharper than the foresail, because the wind is brought more fore-and-aft when it strikes the mainsail.

The same care should also be observed in regard to placing the *main sheet chock* as for the fore-sheet.

TOPSAIL SHEETS.

The hauling part of the top-sail sheets are led through the bitts placed on the forward side of the masts for that purpose and are belayed to a cavil placed in the head of the bitt. Top-sail sheet bitts, in all cases should be sheaved that the sheets may be led aft.

BOLTS FOR JIB AND TOPMAST STAYSAIL SHEETS.

When the vessel has a top-gallant forecastle deck there should be an eye-bolt on either side of this deck to hook the standing part of the jib sheets; and two on each side of the deck for the topmast staysail sheets, one for the standing part and one for the leader. The position of these bolts must be such, that the sheet, when taut, shall form a line at right angles with the luff of the sail, for otherwise, either the foot, or the leech, would become slack, and the sails thus be deprived of a great portion of their efficacy.

BOLTS FOR FORE & MAIN SPENCER, AND SPANKER SHEETS.

One eye bolt is placed on either side of the deck, in or near the waterways for the *fore and main spencer sheets* to hook in, care being taken to place the bolts in such a positionthat the sail may set as flat as possible. A heavy bolt is placed on each side of the poop or quarter deck in the plankshеer or waterway to hook the spanker sheet.

Bolts for Leaders for Topsail Halliards.

One heavy eye-bolt should be placed on either side of the deck opposite their respective masts for the purpose of hooking a leading block for the *fore, main* and *mizzen Topsail Halliards.* In every case an eye bolt is placed in the channels on either side, for the purpose of hooking the single block to which the standing part is made fast. When a vessel carries a battery on her spar deck, *clevis or lewis bolts* should be put in instead of fixed bolts, and placed so as to lead clear of the guns.

MAIN BRACE BUMPKINS.

Main Brace Bumpkins are generally made of wrought iron and placed through the timbers below, or the chock above the poop deck and the inner end keyed; fitted with a brace on the forward and after sides and one below. The standing part and leading block of the main brace are generally secured to it, the hauling part being led in on deck through a fixed block placed above the main rail or in the bulwarks.

Fore-stay Bolts.

In nearly all the modern ships in the U. S. Navy, the *fore-stay bolts* are put in on the forward end of the top-gallant forecastle deck, the eye is formed to shackle a ~~dead-eye~~ too, the bolt in many instances, being driven through the knight heads and set up on the outside with nuts and washers. In other cases it has been placed through a

heavy oak piece let in to the deck for that purpose, passing through the deck hook and breast hook over the bowsprit, secured on the under side of the breast hook with nuts and washers, and in addition with a washer and key (the washer is placed on before driving through the breast hook,) below the deck hook. An oblong plate is let in (in the latter case,) flush on the oak plank, and the bolt is made with an arm projecting forward of the eye which is also secured with bolts clinched on the underside of the hook, adding very much to its strength.

Main-stay Bolts.

Bolts for the *main-stays*, one on either side, are placed through the beam on the forward side of the mast secured with washers and nuts below, or in the waterway, the bolt passing through the waterway, timber and outside planking and riveted on a large plate let in flush with the plank; the bolts being further secured by having an arm forged on the forward side of the eye, which is secured with blunt bolts driven into the waterway. In vessels having a light spar deck with the main-stays close to the mast, two heavy rods of iron are run between decks and shackled to a heavy bolt, secured to one of the gun deck beams, the upper end of the rods being made to shackle the stays too.

Bolts for Top Tackles & Leaders for Top Tackles.

Two heavy eye bolts are required on each side of the several masts for *top tackles* and *leaders for top tackles.*

Bolts for Leaders for Yard & Stay Tackle Fall.

If the vessel has a top-gallant forecastle, one bolt will be placed on it on each side, and so as to lead aft well, for *leaders* for *yard* and *stay tackle fall.*

Bolt for Leader for Fore-stay tackle Fall.

One bolt is required on either side of the deck, abaft the foremast for *leader* for *fore-stay tackle falls.*

Bolts for Main yard & Main stay tackle Falls.

Two bolts are required forward of, and near the mainmast, for leaders for *main yard* and *main stay tackle falls.*

The bolts enumerated above, form only a small portion of those required in connection with the rigging of the ship, but they are among the most important and should be located properly.

In addition to the fittings already considered the following are required:

Fish-davits and steps to ditto.
Stand racks and other fittings for small arms.
Bars, hatch, scuttle, &c.
Benches, armourers & carpenters.
Binnacles and all the fittings connected therewith.
Blocks, beef and chopping.
Boats, stowing of, including chocks, bolts, &c.
Boats, davits & all fittings therewith.
Buoys, life, including fittings for.
Cleats, belaying and cavils.

Coats to mast and mast wedges.
Companions & hoods, over hatchways and skylights.
Cranks between beams for capstan bars.
Chests, mess, arm and signal.
Galley-bed, work connected with. fitting and fixing, including the lead for the bed and tin for covering the beams and deck. and bolts to secure the galley to the deck.
Hand-holds to hatchways.
Hatch-cranes, for striking down and whipping up, shot, shell, provisions, &c.
Hawser and hose reels.
Ladders, accommodation, Jacob's, hatchways, top-gallant forecastle and poop, and bridge, including fittings for.
Lockers for signals.
Ports, half, and bucklers.
Plugs, scupper, side, hawse and stern pipe.
Pumps, fitting, and all work connected therewith, including brakes, &c., for working ditto.
Skylights.
Stantions, awning and man rope.
Steps to ship's side and grab-rods to ditto.
Sentry's walk.
Spare spars, stowing of.
Stand for scuttle-butt and bolts to secure it.

LAUNCHING.

After the carpenters have completed the hull of the vessel, the necessary preparations are commenced for launching. It is the finishing stroke of the ship builder to place her safely in the water.—The transference of so great a weight as *one, two* or *three thousand tons* out of the building yard into the water appears at first sight, an arduous and difficult problem; but, with sufficient foresight and forethought, it becomes so easy, as to be little more than routine.

It is the object of wise launching arrangements to guard against all casualties. First, the launch ought to take place with certainty at the exact time wanted. Second, it must take place easily and with a moderate speed. Third, provision must be made against straining.—These are ordinary conditions to be foreseen but there are sometimes others: the water is shallow, or there is very little room in the water for the ship to run after leaving the ways, or she may have some distance to run to meet the water, and for such special cases, peculiar provisions are required; and the ship may be launched equally well either head foremost, stern foremost, or broadside, on or at any required angle of obliquity with the keel, provided only the following general precautions are taken.

The ruling condition, however, of every case is this: the ship must remain thoroughly well *land-borne*, until she becomes thoroughly well *water-borne;* this is the first difficulty. While the ship is being built she is well supported on the long row of blocks on which her keel rests from end to end; these carry nearly her whole weight. In addition, her hull is kept upright by the long lines of shores, which both under her bilges and all around prevent her from swaying to either side. In this position the ship is finished, and is perfectly *land-borne;* but, before she is launched, she must be raised off all these blocks, and all these shores must be knocked away. The first step then towards launching, is to provide a new series of supports totally independent of those upon which she has been built, and which shall, nevertheless, support her, as perfectly as they have done.

In the mode of launching in our navy yards, this is accomplished by laying down on each side of the keel two independent lines of supports resting on blocks built up at the proper declivity. These two lines of supports consist each of an upper layer of logs and an under layer; the upper constitutes the *cradle*, and the lower constitutes the "*ways*" of the launch.

THE WAYS.

The *ways* consist essentially, of the *blocking*, *launching ways*, *launching ribband*, *ribband shores and back shores.*

The *ways* or lower line of support, forms nothing more than a kind of railroad, serving to conduct the ship into the water. They are formed by laying first, blocks from four to six feet apart, until they reach a height of six feet, when resource is had to cribbing as in building up the keel blocking, to make up the height so as to have the depth of the bilge ways at least in the fullest part of the body, the ways to the proper inclination.

The *launching ways* consist of logs of yellow pine or white oak timber laid perfectly smooth, even and continuous, down the slip on the blocking into the water; the butts of the different logs are shifted, and secured together with screw bolts and nuts, and have the butts rounded slightly on top, to prevent any part of the bilgeway from catching as the ship goes off. The inclination of the launching ways depend altogether upon the weight of the vessel to be launched, ranging from $1\frac{1}{8}$ in the smallest to $\frac{1}{2}$ of an inch to the foot in the largest.

Half an inch to a foot is a dangerously slow inclination. Five-eights of an inch to a foot, is so moderate and gentle that if we wish to control it, we can easily do so, Ships have been cut in two, one-half launched down this angle to its new place, under the control of cables and capstans, and stopped gently, at the precise spot determined for her increased length. The third rate of inclination in use may be called "*free launching*," namely, six-eights of an inch to a foot. On this inclination a ship will move steadily and gently down, without ever attaining a very high speed and this is the inclination one should adopt, if no other circumstances biassed the choice. The next higher rate of inclination is $\frac{7}{8}$ of an inch to the foot; $\frac{7}{8}$ have an advantage over six-eights for a large and heavy ship, because the lubrication of the ways is somewhat less effectual under a very heavy pressure than under a lighter ship. The fault of this angle is the high speed at which it delivers the ship into the water, and which makes her travel far, so as in narrow water to be both a danger and an inconvenience; it is however, a good angle for large ships.

As has been stated in the first lecture about the inclination of the launching way, it will be readily seen that the choice of the place in which the ship is to be built, and the height at which she stands above the water, must all be carefully attended to, when the keel is laid on the blocks. As it is the weight of the ship only, which has to

take her into the water, we have to see, that she is built sufficiently high, to allow the proper inclination of ways to run from where she lies to the place where she is to be water-borne; if this be not carefully pre-arranged, it may be impossible to lay the ways at the proper inclination. If the ship therefore, has to travel 200 feet to get into the water, we must see that she lies 200 inches higher than the place, at which she will float, if she go down 1 in 12 and a proportionately smaller height for each smaller inclination.

Breadth of Surface of Ways.

It is the upper surface of the ways which is lubricated with the well known ship-builder's mixture of tallow and soap, along which the ship has to slide. When the tallow has been so well applied as to form a perfectly uniform coating, and that again has been lubricated by oil, the pressure of the ship on the lubricating material may be such as to squeeze it out, and spoil the lubrication. A ship of war, when launched, may weigh 1000 tons, and not exceed 200 feet in length.—There will therefore, be 500 tons weight on each way, and we have to see that there is lubricated surface enough to carry this weight. Each square foot will carry up to 3 tons; therefore each way, 200 feet long by 2 feet wide, will contain 400 feet; with only a ton on each square foot, the ways will carry 800 tons; with two tons on the square foot, 1600 tons, and so on, therefore, it is quite plain that ways 2 feet wide have ample surface for an ordinary man-of-war. We have only to increase the breadth of the ways or the number of them, till we get the proper proportion to carry the weight, and so long as we keep between 2 and 3 tons as the maximum pressure on each square foot of surface, we have little to fear.

Distance of Ways apart.

The usual distance of the launching ways from each other, from centre to centre, is about *one-third* of the extreme breadth of the ship at the upper end, and *two* or *three* inches wider apart in the length of the ship; this is done to prevent the vessel from becoming *ribband-bound*, as the cradle sometimes spreads a little when the weight of the ship comes on it.

The launching ways are also given an *in-cant*, of one-half an inch in a foot of the breadth of the ways, that their surfaces may present less of an acute angle to the cradle and thus there be less danger of its spreading apart.

Launching Ribband.

In launching, the ship not only tends to slide downwards into the water, but will tend to slide to one side or the other off the ways, on the slightest inclination to either side. To prevent this a piece of oak plank called a *launching ribband* is bolted on the outside of the ways, projecting above it; the butts of the ribband shifting butts with the ways.

Ribband Shores.

Shores called *ribband shores* are placed at frequent intervals on the outside of the launching ways, with their heads placed against the

ribband and their heels fixed against the sides of the slip or otherwise secured. Their use is to hold the ways in place and prevent the ribband from being torn off.

Back Shores.

Two shores called *back shores*, are generally placed on the outside and inside of each way, at the lower end of the slip; the head resting against a heavy cleat bolted to the way, the shore placed in line with the way and the heel properly secured; they are for the purpose of assisting to keep the ways from moving in a fore-and-aft direction, as there is sometimes a tendency of the ways to move that way, when the vessel is launched. The ways are further secured to the blocking by *iron dogs*.

When a ship is to be launched in a direction at right angles to the water's edge, the lower ends of the launching ways lie in one straight line perpendicular to the keel of the vessel. But when the vessel is to be launched obliquely to the water's edge it is often convenient to make the lower ends of the launching ways lie in a line parallel to the edge of the water; care being taken that the upper ends of the bilge ways lie in a line parallel to the lower end of the launching ways, so that both bilge ways may quit their bearing on the launching ways at the same instant.

The lower end of the launching ways usually run into a depth of water such, that by the time the bilge ways quit their bearing on the launching ways, the ship shall be completely afloat.

THE CRADLE.

Having thus finished the lower line of support, we come to the upper line of support which forms a *cradle* for the ship and a carriage on which she may glide along the ways to the water. The *cradle* is composed of the *bilge ways, packing, poppets, poppet ribbands, sole pieces, poppet and packing lashings, and tripping chain.*

The length of the *cradle* for a wooden ship should be about five-sixths of her length.

BILGE WAYS.

The *bilge ways* are two more lines of yellow pine, or white oak logs usually in two or three lengths, having their butts rounded on the lower side to prevent catching on any obstruction there might possibly be on the ways below, and having a hole through the ends where they abut, that a rope lashing may be passed through to secure them together; they lie immediately on the launching ways, and under the ship and form the base of the cradle, and directly on these the ship will be supported, that she shall be entirely carried on them as on two sledges. They have been put under such a part of the ship as they could most efficiently support, and also at such a distance asunder, that no probable sway of the ship, and no impediment that she might encounter, will be like to upset her.

PACKING OR FILLINGS.

In the full part of the ship, the space from the bilge ways to the bottom is filled up with solid pieces of pine, called *packing* or *fillings*.

The quantity of this filling that will be required, depends much upon the shape of the ship. Some vessels rise rapidly up from the keel, and vessels with a sharp floor will require a great deal of filling: other vessels with a flat floor, having their bilges low down, lie very near the cradle and require very little filling. These fillings fit close on the bilge ways on the inside, but are left about three-fourths of an inch up, on the outside, for wedge-like pieces, called *launching wedges;* and before and abaft the solid part of the packing or fillings, the lower piece of filling extends to the extreme ends of the bilge ways, being left up on the outside the same as the other part and for the same purpose.

POPPETS.

Before and abaft the packing, the ship is supported on the bilge-ways by means of upright or slightly raking square logs of white or yellow pine timber, called *poppets*. The number of the poppets varies; they are generally from twelve to sixteen inches square, and are placed about that distance asunder. The lower ends of the poppets are kept in their places by being tenoned into the lower piece of packing on which they rest, or by having a piece of oak plank called a *sole piece* bolted on top of the lower piece of packing, and the whole size of the heel of the poppet cut out for it to rest in. The upper ends of the poppets are made to fit against the bottom of the vessel. Forward, the upper ends of the poppets rake slightly aft, and aft, they rake slightly forward; canting in towards the bottom of the vessel the same as the packing. The heels of the poppets are bolted to the lower piece of packing previous to launching.

POPPET RIBBANDS.

The poppets are held together and braced longitudinally by means of pieces of oak plank called *poppet ribbands;* one is generally placed just below the upper, and one below the lower ends of them—sometimes only one is used forward, when the poppets are short. These ribbands are scored over the poppets and extend far enough to lap a short distance on to the packing. The poppet ribbands are bolted to the poppets previous to launching.

LASHING FOR PACKING.

In the forward and after ends of the packing an *oblong score* is cut through it, and a rope lashing, called a *packing lashing*, is first secured to a half round piece of live oak or lignumvitæ, called a lashing toggle; which is placed vertically across the score on the outside, having a line secured to its upper end and made fast above on deck; the rope is then rove down under the keel and through the score on the opposite side, passed around the toggle and led back; being continued until it is thought there is sufficient to prevent the packing from being forced out, when the weight is transferred from the middle to the outer line of supports.

POPPET LASHING.

In the method of launching laid down in your Text Book, the upper ends of the poppets are prevented from slipping upwards by planks bolted to the bottom of the ship and these are again secured

by *cleats*, bolted outside of them. This is a dangerous practice and should not be followed out. The present method is as follows:—Commencing either at the forward or after poppet; first, make the end of the chain fast to one of the poppets, at the height of a ribband passing it under the keel and around the poppet on the opposite side, continuing the operation until each one has had a double turn passed around each poppet and over the ribband above, and a single turn below, care being taken to see that all the parts are hauled taut as they are passed. The poppets now act as outriggers, the weight of the forward and after ends of the ship resting in the bite of the chains. [Note. The size of the chain used, is for a vessel of the "Antietam" class, 1⅛ inch.]

Preparations for Launching.

The work on the launching ways and cradle having been completed; the day previous to that appointed for launching the vessel, the whole of the cradle is taken apart, the poppets and packing being placed on the platform opposite to where they belong, [I neglected at the proper time to mention the fact, that a *platform* is built the entire length of the vessel, resting on the ribband shores, which answers as a staging to work on, in faying the poppets and packing to the bottom of the vessel.] and the bilge ways are shoved in under the bottom, resting on shores placed between the keel and launching ways for that purpose. The upper part of the launching ways and lower side of the bilge ways are next payed over with a composition of tallow and castile soap, and then with fish oil; the tallow to fill up the pores of the wood and give a perfectly smooth surface, and the oil to lubricate that surface.

The bilge ways are then shoved back again on the launching ways and the several pieces which go to make up their length are secured together at their butts by rope lashing, passed through the *scores* in their ends; they are kept about an inch clear of the inside of the launching ribband, by means of small pieces of wood called *toggles*, placed between the bilge way and ribband; this opening is filled up with oakum all fore-and-aft to keep out any dirt, and the portion of the ways below the cradle, should be covered over with loose boards for the same reason. The upper end of the bilge way has an oak plank from four to six inches in thickness, let down flush on top and securely bolted to it, called a *sole piece*; it projects some four or five feet on to another piece called a *chock*, and is securely fastened by screw bolts passing through the chock and ways, and set up below with nuts and washers; it is this plank or sole piece which is finally cut, when the time for launching arrives. The cradle is then again replaced, and the launching wedges are now placed about a foot apart between the bilge way and packing, all along the cradle; the chain lashings on the poppets and rope lashings on the packing are passed and properly secured; the services of the Boatswain and a gang of riggers being required for this purpose.

Meanwhile, other precautions and matters of forethought have been attended to. If the vessel is to be launched in a narrow stream, powerful wharps and cables should be carried out from the ship and made fast to anchors or moorings ashore, to bring up the ship and stop her

way in the water; they should be properly looped up to the ship and laid clear of all possible entanglement so that, in going down, they may drag no obstacle with them; on board, anchors and cables have been made ready to let go, when the hold of an anchor may be required. Special precautions are required for the immediate removal of the entire cradle, bilge ways and packing from under the ship the moment she has taken the water. For this purpose a chain cable of about 1 or 1⅛ inch link called a tripping chain is provided; it is middled and the bite made fast generally to an anchor buried at the upper end of the ways, and the ends are secured to bolts in the upper ends of the bilge ways; the parts of the chain are then led down on the inside of the bilge ways and stopped up out of the way with rope yarns; the cables are sufficiently long not to come taut until the ship is quite afloat; by this means the bilge ways are suddenly brought to a stand still, while the ship is still moving powerfully away; thus the ship, of herself, leaves the cradle behind, the weight of the chains on the poppets causes them to turn bottom up, clear of the ship, the toggles in the packing are drawn out and the various portions which compose it are seen floating away from her on both sides. In the space allotted to the engines and boilers, *shores or braces* are placed, to prevent the bilges from springing when the weight of the ship comes on the two outer lines of supports or ways; one set of shores are placed with their heads in the throats of the hanging knees of the deck directly above, and their heels resting on the side or boiler keelson, as near over the line of the ways as they can be got; from the heels of these inclined shores horizontal shores are placed resting on top of the sister keelsons and against the side of the main keelson. A stantion or heavy shore is also placed under every beam from the top of main keelson. To prevent the long wooden vessels of the "Wampanoag or Florida" class from hogging, the following plan was adopted and successfully used: Three pieces of yellow pine timber 14 inches square called *king posts* were placed vertically, on top of the main keelson, extending 26 feet above the spar deck; one piece through the forward hatch, one through the boiler hatch, and the other through the after hatch; all properly braced and secured in the hatches of the respective decks and below in the hold; on the head of each king post a heavy wrought iron band was placed, having eyes worked on all four sides; at the foot of each king post wrought iron straps having an eye in the upper end, were securely bolted to the sister keelsons; an inch and an eighth chain cable was then shackled between each post at their heads and carried down forward-and-aft to a breast and stern hook to which they were secured; a chain was then led from the head of each post to the strap on the keelson opposite the heel of the post next forward or aft of it and shackeled to the eye in the strap. This made as complete a *truss frame* as was required, and no apparent alteration in the sheer of the ship could be detected after launching, as had been the case in vessels of this class that were launched in other navy yards without the *truss or hog* frame. A hawser was carried over all parts of the chain and stopped to it at short intervals, to hold it from flying and causing any damage should it be parted by the great strain brought on it.

[Note.—This *hoy* or *truss frame* was first used by Naval Constructor B. F. Delano, U. S. N., in launching the "Wampanoag and Madawaska," vessels 335 feet in length.]

The ship still rests as she was built on the slip, and the cradle is merely placed but carries no weight. Two things are now to be done: the whole present supports of the ship are to be removed, and the whole of her weight is to be transferred to the cradle. This is to be done gently, bit by bit. All the necessary preparations for launching having been made; an hour before the tide will be at its height, a large number of shipwrights are ranged in gangs of from four to six each, at short intervals on each side of the vessel, each gang armed with an iron shod battering ram, and at a given signal from the Naval Constructor, they strike the wedges as with one blow from stem to stern, till the whole cradle steadily and strongly rises, pressing the filling pieces up so strongly against the bottom of the ship that they begin to carry a part of her weight and to lighten her load on the building blocks. Every other keel block is now removed commencing from aft, and every other wale and bilge shore taken down.—When this is completed, the shipwrights again drive in the wedges until they can do no more; the remaining keel blocks are now removed, and the shores taken down. In heavy ships, the desire of the ship to go begins to express itself before the time arrives; a strain visibly comes on everything which tends to keep the ship in its place, and as no materials are perfectly rigid they begin to show that they are under a strain and those that are too much pressed sensibly complain The only thing that now remains to be done is to cut the sole-pieces which connect the bilge ways to the launching ways, which is done with a cross cut saw, by carpenters stationed there for the purpose. The word is passed from aft by the Assistant to the Constructor, "*All clear sir!*" the order is given Cut the ways! and off she goes into the water, being baptized by some lady as she commences to move down the ways. In some cases the vessel has refused to move after the sole-piece has been cut, and in the event of this happening hydraulic rams are used, one placed against the end of each bilge way, and if necessary, one under the fore foot of the vessel; as soon as a strain is put upon them the vessel will most likely move off.

On completing the Launching of Ships which have stopped on their Launching Ways.*

The *Caesar*, a 10-gun two-decked wooden ship, having been prepared for launching, was attempted to be launched on the 21st of July, 1853, at the Royal Dock yard, at Pembroke, South Wales, but after she had slid down the launching ways some 80 feet, and thus immersed her after-part in the water at high tide, she stopped entirely, and all the subsequent efforts made that day to move her were of no avail. The declivity given to the launching ways was the usual amount and the plank and material used in the ways were also of the usual description.

*From transactions of the Institute of Naval Architects.

Between the 21st and 26th July, some small hollow vessels built for the purpose, and a few casks, &c., were put under the ship's bottom below high water mark, with the view of reducing the weight of the ship on the ways, and at the time of high tide efforts were then made by means of purchases to pull the ship off, but all these measures were unavailing.

The plan was then advocated of the necessity of building camels for breaking the too close contact that appeared to be established between the bilge ways and launching ways, by lifting the stern of the ship so as to take its weight of the launching ways. Three large camels were therefore ordered to be laid off in the mould loft, in a few hours to fit each buttock, 72 feet long, to be planked with 4 inch plank, and one for the stern. 20 feet square in section and 48 feet long, to be built of 5 inch plank, the collective lifting power when properly in place being estimated equal to 1100 tons. In nine days these camels were finished and launched; they were got in place at low water and secured by bearers put out at the quarter ports on the lower deck, and shored to the main deck upper sills, to keep in place the quarter camels; a similar plan having also been adopted to keep down the stern camel, without any pulling power being applied, the ship about one and three quarter hours before high water abandoned her unworthy connection with the land, and glided gracefully into the water.

On the 17th of March, 1866, the "*Northumberland*," an iron frigate 400 feet in length and weighing over 3000 tons, stopped on her launching slip; a second set of ways were laid with the same inclination as the first and mooring lighters were placed under her quarters and alongside aft, but they failed to launch the ship.

Immediately after this failure, four camels, two for each quarter, were built in a very few days, and they were secured in place by the 17th of April, (just one month from the first attempt to launch the ship being made,) and on the rising of the tide, they lifted the ship abaft off the launching ways, when she glided into the river without the help of the large pulling power which had been provided.

The advantages obtained by the use of camels, are due to the fact that they take all the weight of the ship off the bilge ways, except the extreme fore end, so that the after part is lifted clear of any obstruction that may exist, or where the grease used is bad or insufficient in quantity, the adhesion of the surfaces in contact is overcome and they are left free to slide upon each other.

To the foregoing it may be added that due consideration should at all times be given in preparing the "*launch*" of a ship to the relative weight of the ship and area of launching ways, declivity of the launching slip, and to the time it is intended the ship shall rest in her cradle before the launch takes place, then finally on the kind and quantity of grease to be used between the sliding surfaces. All these points effect the *stiction* to be overcome in launching the ship

NINTH LECTURE.

SUBJECT:—*Composite Ships; Jordan's System of Constructing Composite Ships; McLain's System of Constructing Composite Ships; Scott's System of Constructing Composite Ships; Daft's Method of Sheathing Iron Ships; Grantham's Method of Sheathing Iron Ships; English Admiralty Method of Sheathing Iron Ships; Docks; Wet Docks; Dry Docks; Method of Docking a Vessel in a Dry Dock; Floating Sectional Dry Docks; Method of Docking a Vessel on a Sectional Dock; Marine Railway; Balance Floating Dock; Method of Docking a Vessel on a Balance Floating Dock.*

Composite Ships.

The principle object in building *composite ships* is to combine the durability and small friction of copper sheathing upon a wooden bottom with the greater strength, lightness, simplicity and cheapness possessed by an iron frame.

A principal requiring special attention in composite ship-building is, that every piece of iron must be completely *insulated* or cut off from electrical communication with any piece of copper or its alloys; otherwise the iron will be rapidly corroded.

One thing should be kept in mind in composite ship-building, which is, that while the expansion of wood by heat is insensible, that of iron is about 1–800th of its length for the difference of temperature between the freezing and boiling points of water. This fact leads to the belief that it is better, in composite ship-building, to make all the pieces which lie fore and aft, of wood, and all those which lie athwartship or diagonally, or which stand upright, of iron, rather than to combine pieces of different materials in positions parallel to each other.

Jordan's System of Constructing Composite Ships.

The system of composite ship-building most generally practiced, is that known as "Jordan's System," in which the whole outer skin, including keel, stem, stern-post and planking, is of wood, arranged as in the skin of an ordinary wooden ship; and the frame-work inside of the skin, including frames, beams, keelsons, stringers, shelf pieces, water-

ways, hooks, transoms, diagonal braces, etc., is of iron, arranged nearly as in an ordinary iron ship—"*channel*" or trough-shaped iron being used for the frames.

The bolts which fasten the skin to the frames are of iron, generally "galvanized" or coated with zinc; and their outer ends are countersunk in holes of such a depth that the iron bolts can be electrically insulated from the copper sheathing by plugging the holes with pitch or other suitable non-conductor of electricity.

See Diagram.

McLain's System of Constructing Composite Ships.

The difficulties incident to keeping a vessel perfectly tight are very serious, and I propose, in preference, to keep the leakage free from the iron of the structure by building vessels with keel, stem, stern-post, frame and outer planking, nearly the same as those of an ordinary wooden vessel; but instead of the ceiling or inside planking being composed of wood, it is to be constructed of iron, united all round at the bottom and ends of the vessel, and made thoroughly water-tight, forming a complete inner skin, with beams, stringers, keelsons, bulkheads, platforms, &c., also of iron. (See Figs. 1, 2 and 3, on black-board.) The greater part of the wooden frame is merely of dimensions sufficient for bolting the wooden planking to, and is inserted between iron frames riveted all round the outside of the iron ceiling. The wooden frames are fastened to the iron frames by galvanized iron fore-and-aft bolts, either screwed or plain. The wooden floorings are made deep in the throat and stiffened with plates on each side, riveted to the angle iron frames, or iron floors are fitted inside the iron ceiling to supply the requisite transverse strength.

The apron, inner post and deadwood, are inserted between and bolted to large angle irons riveted on the iron ceiling. The outer planking within the influences of the copper sheathing to be fastened to the wooden frame with screw tree-nails or with yellow metal bolts. The top timbers of the frame are, by preference, composed of teak, and in the wake of the armour plating the spaces between the frames are filled in solid with teak, or with any other suitable material; the iron ceiling is also increased in thickness, and additional welt frames are introduced at intervals to resist shot and strengthen the vessel.

See Diagram—Figs. Nos. 1, 2 and 3.

Scott's System of Constructing Composite Ships.

The diagram on the black-board (No. —) represents part of the side of a ship built according to Scott's system.

The frames are of **T** iron, instead of angle iron, all fore-and-aft the ship, and, being stronger, they are spaced further apart.

Betwixt the frames are fitted chocks of teak bolted to the frames with iron bolts, and caulked throughout—forming, in fact, a water-tight ship.

Over these chocks and over the frames is wrought the outside planking, which is fastened, as shown in the drawings, by brass bolts, which pass through the chocks and planking, and which may be either clenched or screwed with nuts.

It will be observed that the planking overlaps the seams of the chocks, so that there are no through seams.

With existing appliances, the frames fore-and-aft will be somewhat more difficult to set to the figure of the ship than frames of angle iron; but, on the other hand, the number of frames to be set is less than in the ordinary method of building composite ships.

Thus, in a vessel 200 feet long, the number of frames would be fewer by at least twenty.

See Diagram.

Daft's Method of Sheathing Iron Ships.

Daft's method of sheathing iron ships with copper, mixed metal or zinc, is as follows: The inner layer of the iron skin consists of narrow strips of plate, merely wide enough to make lap joints with the outer layer, and to leave a groove between the edges of each pair of outer plates about as wide as the plates are thick. Into that groove is inserted a filling of teak or of ebonite, (a hard compound of caoutchouc and sulphur.) Outside the plating is a layer of tarred felt, about $\frac{1}{4}$ inch thick, upon which the sheathing is laid, and fastened with sheathing nails of the same metal, driven through the felt into the teak or ebonite fillings. Intermediate fastenings are obtained, if required, by inserting ebonite plugs into holes drilled in the iron plates, and driving sheathing nails into them through the felt.

The tarred felt serves to insulate the copper or mixed metal from the iron. It may be used with zinc sheathing also, but is not then absolutely necessary; for zinc, being electro-positive to iron, protects the iron against oxidation.

During some experiments made in 1864 in England, it was found that *zinc sheathing upon iron* lost about .002 inch of its thickness by

six months exposure to sea-water, and remained free from shell-fish and sea-weed, like copper or yellow metal.

See Diagram.

Grantham's Method of Sheathing Iron Ships.

Grantham's method of sheathing iron ships with copper or yellow metal, is as follows: Outside the iron skin are riveted angle-iron ribs, whose projecting flanges are of a dovetail shape in section. An equal weight of iron is saved in the inside framing. The iron skin is then coated with pitch, and the spaces between the dovetail flanges are filled by packing and wedging into them short pieces of plank. The outside ribs, with their wooden filling, rise to a short distance above the water-line, and the upper edge of the filling is guarded by a longitudinal angle-iron. The outer surface of the filling having been payed with pitch, a complete wooden sheathing, about $1\frac{1}{2}$ inches thick, is put on and fastened to the filling pieces with mixed metal nails, which should not pass through those pieces. The wooden sheathing is then pitched, and is sheathed with copper or mixed metal in the usual way—care being taken to keep the metal sheathing two or three inches from any exposed piece of iron.

See Diagram.

If the main internal framing be vertical, the external frame may be longitudinal; or, if the main internal framing be longitudinal, then the external frame may be vertical; the effect of either plan is, that both frames may be attached direct to the shell, and cross each other's path without either being cut into short lengths, as must be the case when both horizontal and vertical frames are attached on the inner side only.

English Admiralty Method of Sheathing Iron Ships.

In 1869, several iron vessels built for the English Navy, were sheathed on a plan almost identical to that proposed by Mr. Grantham. They have brass stem and stern-posts, a sheathing of teak 3 inches in thickness, laid fore-and-aft and tap-bolted to the shell of the ship; over this, shifting bolts and seams, is an outer course of the same thickness, made of lighter wood, and secured to the inner one by brass, wood-screws. The wood sheathing is caulked and payed with pitch—over which the sheathing of copper is to be applied; in all these points

the plans correspond. The mode of attaching the inner course is the point on which the respective plans differ.

See Diagram.

Docks.

There are several kinds of *docks;* the principal ones are the *wet, dry, sectional* and *balance docks.*

Wet Docks.

Wet docks, on the grandest scale, are to be seen at London and Liverpool; at these places there is a great *rise* and *fall* of the tide, and these *wet docks* are a kind of artificial harbors, where there is water enough at all times to float the vessels loading and unloading—the vessels being taken in and out of them at high-water. These docks are closed by means of *iron cassions.*

Dry Docks.

Dry docks are used for building and repairing vessels in. In England's dock-yards there are at present *twenty-seven* dry docks completed and *thirteen* in course of construction. Most of the English iron-clads are built in docks. The advantage derived over that of building on *slips,* is as follows:

1st. No weights are required to be raised to elevated positions—an important item in building heavy vessels.

2nd. The workmen within and without the vessel are under the eye of the foreman; for, from the edge of the dock, he can, up to the time that the decks are laid, view all of them.

3rd. In building the vessel she lies on an even keel; all the work, therefore, can be fitted to correspond with plumb-lines.

4th. The most important point of all gained is, that the severe strains a vessel is subjected to in launching are avoided. In the United States navy-yards there are *three* dry docks—one at Brooklyn, N. Y.; one at Charlestown, Mass.; and one at Portsmouth, Va. These docks are closed by *cassions* or *boat-gates,* which are iron vessels about *sixteen feet beam,* having a keel and stem made to fit in the grooves in the masonry at the entrance to the dock. By admitting water in the cassion it settles down in the grooves and closes the entrance to the dock, or is removed by pumping the water out of it—a small steam pump being used for this purpose.

Turning gates are placed inside the dock so that the cassion may be docked, if necessary, to repair it at any time.

Method of Docking a Vessel in a Dry Dock.

When a vessel is to be docked, the *keel* and *bilge-blocks* are first *regulated*, that is, the keel-blocks are laid to the *shape of the keel*, and the bilge-blocks made to fit the *bilge of the vessel*—*moulds* of several *cross-sections* of the vessel being furnished from the *mould-loft* (if necessary) for this purpose. The blocks having been properly regulated, the *filling culverts* are opened and the water admitted into the dock until it finds its level. The *filling culverts* are then closed, as well as the *dock chamber* to the *draining culverts* leading to the *pump-well*, and the water is pumped from the *latter*. The *caission* is then floated and hauled out of the way, and the vessel hauled into the dock and secured in the *centre* of it with hawsers from either bow and quarter and one ahead. The *caission* is now placed in its proper position and filled with water by opening a valve in the bottom, until it rests in the grooves of the dock. The *turning gates* are also closed. The *culvert gates* in the *dock chamber* are now opened and the water allowed to flow into the *draining culvert* and *well*. By this means the water is lowered about a *foot* in a few moments, and an immediate pressure brought upon the *gates* to prevent the admission of water and fix them steadily. A complete command of the level at the moment the ship is about to touch the blocks, and require the placing of shores is important, as it gives a more perfect control of the operations for the *first foot* than could be obtained by the best regulated pumps and machinery for driving them. The water remaining in the dock (about 600,000 cubic feet) is afterwards pumped out of the *well* into the *reservoir*, from which it is discharged through a *culvert* into the river. The *shores* are placed first from the side *altars* to the side of the vessel, called *breast-shores;* then a set of *vertical shores* are placed around the vessel at the *wale height*, called *wale-shores*—heavy cleats being screw-bolted to the vessel over the heads of them. This is done as soon as the vessel touches the blocks—the pumping being suspended in the meantime; as soon as this is completed, the remainder of the water is pumped out and the *bilge* and *bottom shores* placed in position. Blocks, called *bilge blocks*, are hauled under the *bilges* as soon as the vessel grounds—ropes lead from them to the top of the dock for this purpose.

Floating Sectional Dry-Docks.

The Government owns *four floating sectional dry-docks*, viz: *two* at Philadelphia, *one* at Brooklyn and *one* at Mare Island, Cal. Navy Yards.

The *sectional docks* at Philadelphia Navy Yard, are composed of *seven* and *nine sections* respectively: The *sections* consists essentially of a *main tank*, *two end frames* and *two floats*. A *truss* and *bulkhead* extends through the centre of the *main tank*, directly over which are placed the *keel-blocking*. At right angles to the line of *keel blocks*, *bilge block ways* are fitted to the deck of the tank, upon which *bilge blocks*, suited to the proper form of the vessel, are slid (by means of ropes extending to the platform on the inside of the deck above,) for the purpose of sustaining the vessel. *Horizontal shores*, graduated to *feet* and *inches*, extend from each *end frame*, and are made to *slide*

out or *in*, to reach the side of the vessel and keep her in the *centre* of the dock until the *keel blocks* are brought against her keel. There is placed in each *end frame*, at either side of a *section*, a *float* connected with *four posts* of the *frame work*, by *two shafts* with small *cog wheels* on each end, which work into *pinions*, properly fastened upon *one side* of each of these posts, by which the machinery *raises* the *end floats* when *lowering* the *sections*, and forces them *down* when *raising* a vessel; they serve as an equilibrium power, to keep the ends of the *main tanks* on a *level*. The *sections* are joined together by means of a *sliding beam* on each side of the *main tanks* above, so arranged that they can be slid apart from *three* to *six feet*, to take up any desired length of vessel, but *three feet* is the usual distance. At the end of each *main tank* are *one single* and *one double pump*, which, together with the *floats*, are operated by an engine situated each side and on top of one of the sections. The *shafting* which conveys the power of the engines from one section to another, runs into a *hollow sliding-shaft*, and may be *slid in* or *out*, corresponding to the distance the sections are *spread* by the *connecting beam*. Between the sections there is an *universal joint* in the shaft, to provide for any deflection there may be in the line of shafting extending along and over the platform.

Method of Docking a Vessel on a Sectional Dock.

When a vessel is to be docked, the *main tank* is filled with enough water to admit of sinking it, the *end floats* are *run up* as the *dock sinks down*, and their speed regulated so as to keep it *level* at all times. When the *keel-blocks* have been submerged a foot or two more than the draft of the vessel to be docked, the ship is hauled in and placed by the *graduated wale-shores* in the *centre* of the dock. The *pumps* are *started* and the *floats worked down* until the *keel-blocks* have a bearing on the *keel* of the ship. The engine is now stopped, and the workmen pass rapidly from one section to another on the platforms, and by means of the ropes reaching to each platform, haul the *bilge-blocks*, now under water, with great facility, against the bilge of the ship. The *pumps* and *floats* are now set to work until the *deck* of the dock is raised above the water.

If desired, the vessel can now be taken in the *basin* opposite a *Marine Railway*, and the vessel hauled ashore, leaving the dock clear for another vessel.

Marine Railway.

The *Marine Railway* consists of *three parallel ways*, the top surface of which is level with the deck of the sections. The *centre way* is intended to sustain the vessel on her *keel* when undergoing repairs; the *other two ways*, at equal distances from the *centre way*, answer the purpose of a *launching way*, on which the *bilge way* and *cradle* rest during the operation of hauling the vessel on shore. The *cradle* is constructed in the same manner as for launching from an *inclined slip*. *Temporary ways* are laid upon the deck of the dock, being a continuation of the ways on shore. The *bilge ways* are got in place, and the *cradle* placed in position. The *hydraulic cylinder* is

attached to the head of the *sliding frame* by large wrought-iron *hauling beams*, and the movement commenced, which draws the vessel along *eight feet* at a time, until the vessel is off the dock, and on the *bed ways* in the Navy Yard. If the *bilge ways* are required for another vessel, they can be taken apart readily. *Shoreing ways* are arranged on either side of the *ways* similar to those in the ship houses.

Balance Floating Dock.

The government owns *one balance floating dock* at the navy yard, Portsmouth, N. H. It may be described in general terms as a combination of a *cassion* and *camel*, united in the form of a *walled dock*, having a *middle compartment*, in which the vessel rests after the water is pumped out. This combination is made by butting the *side compartments* or *balancing chambers* with *sloping inner walls* into a *cassion*. It is called a *balance dock* from the facility of preserving an exact *equilibrium* and *level* by *pumping out* or *letting water into* the *separate compartments* of either of the *side chambers*, of which there are *eight* of the *compartments* in each *side chamber*, all communicating with the *pump-well* in the *centre* of the chamber. The portion of the side above the *windows* is called the *ballast chamber*. The dock being entirely constructed of *yellow pine*, it will not sink of its own specific gravity low enough to admit vessels of great draft, and in order to sink it down to receive vessels of great draft, water is pumped into these *ballast chambers*.

There are gates at the ends of the dock which can be closed when vessels of great weight are to be raised.

Method of Docking a Vessel on a Balance Dock.

Preparatory to docking a vessel the *discharge gates* are *closed* and the pumps set in motion and the *chambers* filled to the height of the deck of the dock; it is then allowed to flow into the *upper chambers* until its weight sinks the dock to the required depth. *Two hundred* and *forty tons* of water are required to be pumped into the *upper chambers* to sink it deep enough to take on a ship drawing 25 feet of water. When the ship is in dock and in position to be raised, this *ballast* is drawn off by opening valves in the lower *side chambers*, thereby causing the dock to rise by its own specific gravity until it touches the *keel* of the vessel. The pumps are now started, the water pumped out of the *side chambers* and *bottom tank*, and as the dock rises with its load, the water in the *middle chamber* ebbs out. The time ordinarily required to raise a vessel is about *two hours*.

TENTH LECTURE.

SUBJECT: Iron Ship Building, Preparation of Model and Arrangement of Outside Plating, Mode of Ordering Plates and Angle Irons, Laying-Off of the Ship, Preparation of Frame Angle Irons, Preparation of Keel Work, Stem and Stern Posts, Stems, Stern Post, Iron Beams, Preparation of Beams, Process of Framing, Preparation of Floor-Plates and Reversed Angle-Irons, Description of Ordinary Mode of Plating a Ship, Mode of Working Deck Stringers, Method of Taking Account Of and Working Plates with Large Amount of Curvature or Twist, Ordinary Arrangement of Riveting in Outside Plating, Deck Planking for Iron Vessels, Preparation of Bulkheads, Putting in Rivets and Testing Rivet Work, Caulking Laps and Butts of Plating.

IRON SHIP BUILDING.

In this lecture I propose to give a brief outline of the general method of proceeding with the work of building iron ships. The descriptions given are based upon the method practiced by some of the principal firms in England; but as most ship-builders have peculiar methods of performing some portions of the work, it would be impossible to give any general description which would include all these special cases.

Preparation of Model of and arrangement of outside planking.

The order in which the work is usually conducted is as follows:—A model of the ship on a scale of $\frac{1}{2}$ inch to a foot is prepared immediately after the drawings have been received, and on the model the general arrangement of the edges and butts of plating, the directions of the longitudinal work, deck lines, &c., are drawn. That no confusion may occur in ordering the plates from the manufacturers, and that a correct account may be given to the workmen, it is customary to work the strakes, in order, alphabetically, and to number the plates in each strake. The lengths of the plates used are regulated by the specification, averaging, about 10 feet.

Mode of ordering plates & Angle Irons.

The lengths of the frames, reversed angle-irons, &c., are taken from the body plan on the mould-loft floor. The dimensions, actual weights, and particulars of the results obtained by

the testing of both plates and angle-irons are recorded in an order book, and in case where the plates have a peculiar shape there is a rough sketch given of the form to which they must be brought by the manufacturer. A margin of *one inch* in length and *one-half inch* in breadth is allowed in the dimensions recorded in the order book above the net dimensions of plates on the broadside of an iron ship; but forward and aft where there is considerable curvature and twist, a greater margin is given. *Floor-plates* are usually ordered to the required taper, and afterwards bent to the proper curves. When *centre plate keelsons* are adopted, each of the floors is in two separate pieces. In ships with *bar keels* each floor is usually made up of two pieces welded together, the welds of adjacent frames being placed on opposite sides of the middle line in order to give a good shift.

Laying Off of the Ship.

The *laying-off of the ship* is proceeded with simultaneously with the preparation of the model, and when it has been completed, the lines to which the angle-iron frames are to be bent are transferred to boards prepared for the purpose, and rased in. There are two boards, each being large enough to take the midship section of the ship, the fore body being transferred to one and the after body to the other. In order to show the lines more clearly, the upper surface of these boards are covered with a composition of lamp-black, size, and water. The name commonly given to these boards by the workmen is the "*schrive*" or "*schriveing*" *boards*, but I shall refer to them as *blackboards* throughout the following description. In addition to the lines to the outside of the frames, the position of the *plate edges*, *diagonals*, *level lines*, *heights* of *floors*, *beam ends*, &c., (which answer for bevelling spots), are marked upon the blackboards, which are then removed to a place appropriated for the purpose situated near the furnace in which the angle irons are heated. In the transverse system of framing which this relates to, the frames are formed by a frame angle iron and a reverse angle iron riveted to it; the floor plates riveted to the frame angle iron at the lower edge, the reverse angle iron being carried across on the upper edge of the floor plate and riveted to it with an angle iron on the opposite side of the floor plate, the rivets passing through and connecting all three together.

The various modes in which floor-plates are fitted, are regulated by the arrangement of keel which is adopted.

In vessels which have external solid-bar keels, the floor plates usually cross the middle line, while the frame angle-iron ends at the middle line, in many cases. A strap of angle-iron about 4 feet long of the same size as the frame angle-iron is riveted on the opposite side of the floor-plates in most vessels where

this arrangement is adopted, and so keeps up the transverse strength of the frame and secures the bottom-plating. Sometimes however the frame angle-iron is continued across the middle line.

The *limber-holes*, as a general rule, are cut in the floor-plates, above the frame angle-iron, and to prevent water lodging in the spaces below, they are usually filled up with cement.

When *hollow-plate keels* are adopted the arrangements of the floor-plates is exactly similar to that just described for a bar-keel; the frame angle-irons, however, in these cases generally run across the keel, and the hollow keel itself forms the water course.

Note. [The hollow plate keel was used in the construction of the iron monitors and iron tugs in our service.]

Preparation of Frame Angle Irons.

The *leveling blocks* or *bending slabs* on which the frames are bent are made of cast iron, the upper surface being straight and out of winding, and perforated with holes placed at intervals of about 6 inches. The line to which the frame is to be bent is transferred from the blackboard to the slab by means of a soft iron bar, known as a "*set*" iron (about $1\frac{1}{4}$ by $\frac{3}{8}$ inch) which is bent to the line on the board, has the bevilling spots, &c., marked on it, and is then removed to the slab, on which the curve is drawn and the spots are marked.

The *bevillings* are given out on a separate board, as in wood ship-building, and are applied to the back of the angle-iron. Care has to be taken in bringing the flanges to the correct bevilling to avoid striking too heavily, as the angle-iron, even when of good quality, is liable to open at the root under very heavy blows. The backs of the flanges are also liable to become hollowed while the bevilling is being performed unless special care is taken to keep them straight, which, it will be obvious, is an essential condition for good work, for otherwise the flange would not fit accurately against the plating.

The bending and bevilling having been completed, the angle-iron is allowed to cool, and is then taken to the blackboard and tried to its curve, any unfairness of alteration of form which may exist being corrected. The plate edges and other stations before enumerated, are notched in on the frames, and the rivet holes for the outside plating are marked, the pitch varying from six to eight diameters, according to the space between the plate edges. The spacing of the rivets for the reversed angle-irons is regulated by the rivets in the outside plating, the rule observed being that no two rivets shall come in the same transverse section of the angle-iron frame, as its strength would otherwise be seriously reduced.

The average pitch of the rivets in the reversed bars also is six to eight diameters. The holes in the frames should be punched from the back in order that the countersink obtained by punching may assist in keeping the rivet in place. The holes in the frames which receive the rivets in the plate edges are generally drilled after the ship is framed and the plate edges faired and marked in. When the punching has been completed the frame is again tried to the curve on the board, and any alteration of form caused by punching is corrected.

Preparation of Keel work, Stem & Stern posts.

While the frames are being prepared, the *keel* is proceeded with and temporarily put together on blocks alongside the dock or slip where the ship is to be built. This course is adopted whatever may be the character of the keel, whether bar or flat plate. When the keel is made ready, the frame stations are painted upon it, and it is taken to peices and removed to the permanent blocks in the dock or slip, where it is put together again and riveted up. The fore and after ends of the keel have been previously prepared so as to *scarph* with *stem* and *stern posts* respectively, and it is usual to make the moulds for the stem and stern post at as early a stage of the work as possible in order that they may be forged, and that no time may be lost in waiting for their completion. The work amidship is often well advanced, however, before the stern post is got in place. It is usual to drill all holes in connection with bar keels, and in all work where three thicknesses come together the holes are drilled in the middle thickness, and punched in the outer thicknesses in order to secure their being well filled by the rivets.

STEMS.

The *stem* of an iron ship is generally a prolongation of the keel; the iron stem at present in use in ordinary iron vessels is simply a curved solid bar of uniform section, or nearly so, generally forming the contour of the bow, even where a projecting knee forming an ornamental head. Lloyd's Rules simply provide, that the keel and stem shall be scarphed or welded together, if scarphed, the length of the scarph must be eight times the thickness. The Liverpool Rules require that the feet of the stems shall be extended so as to form part of the keel, not less than 4½ feet long.

Stems formed and fitted with special regard to their adaptation for forcing or ramming in the sides of other ships, the consideration of expense, which so largely controls the designs of mercantile vessels, is here subordinate to other considerations; and the forgeing and planing of the stem into any desired shape is held to be justifiable. The first thing to be accomplished is to give to such a stem the support of all the bow bottom plating and armour-plating in delivering a horizontal blow. For

this purpose all such plating is let into the substance of the stem, abutting squarely and closely against the fore side of the rabbet; the stem being made deep enough in front of the plate-ends to form a sufficiently stout abutment for them, and deep enough abaft the rabbet-line or, in other words, affording sufficient surface for the skin-plating to receive a double row of bolts through that plating. In the wake of armour, the stem has to be formed sufficiently deep to receive not the armour only but the skin-plating behind it. Somtimes these large stems are formed in two peices, connected by a carefully fitted hook scarph, eight 1 inch rivets passing through the scarph to secure them together.

FORGING AND PLANING OF STEMS.

The stem of all H. M. iron-clad frigates are formed of the best scrap-iron under the steam-hammer. The stem having been forged, is sometimes bent to form and planed afterwards, and at other times planed first and bend. The best method is to plane it first and bend it afterwards; but the planing in that case occupies a long time and is very costly, owing to the planing tool having to be made to travel round the varying curvature of the stem.

The mode of bending stems varies. The stems of the "Minotaur" and "Northumberland," Enghish iron-clads, were bent on levelling slabs used for bending ship-frames, a coke fire being made round a length of about 8 feet at a time; and when the heat was sufficient, the fire was removed, and the bending affected by means of wedgesetts, a tackle and crab, and other like appliances. This operation was repeated until the whole length was brought to the required shape.

Stern Posts.

The *stern posts* of iron ships admit of the same variety as keels and stems. Solid bar posts are now used being scarphed or welded to the keel in the same manner as the stem is secured. If the stern post be scarphed the length of the scarph must be eight times the thickness of the keel. Stern post now in universal use are solid forgings. The forward post in screw ships is fashioned to receive the engineers shaft tube, in wake of the shaft, and the rudder post has the lugs or braces for carrying the rudder, either forged upon it, or secured to it by forked arms, embracing it and riveted to it. The two posts are generally forged in one piece.

IRON BEAMS.

Lloyd's rule with respect to the form and depth of *beams* is as follows:—"Beam plates to be in depth one-quarter of an inch for every foot in length of the midship beams, and to be in thickness one-sixteenth of an inch for every inch in depth of the said beams, and to be made of H iron, T bulb iron, or bulb

plate with double angle irons riveted on the upper edge; the two sides of each of these angle irons to be not less in breath than three-fourths the depth of the beam plates and to be in thickness one-sixteenth of an inch for every inch of the two sides of the angle-iron; or the beams may be composed of any other approved form of beam iron of equal. Where beams below the upper or middle deck (including orlop beams) have no deck laid upon them the angle-irons on their upper edges are required to be of the same dimensions of the angle-irons of the reverse frames."

The Liverpool Rules require that the beams shall be formed of bulbed iron with strongly bulbed lower edge, with double angle-irons on top edge, or of bulbed T iron, or of any other approved form, and their regulation as to depth is almost identical with that of Lloyd's Rules. The bulb iron now generally used for deck beams is rolled in one, and the angle-irons on the upper edge are worked after the bulb iron has been bent to the round up. The form of beam now commonly employed, especially for upper deck beams, is known as the "Butterley Patent Welded Beam," its section is shown on the blackboard, up to 12 inches in depth they are rolled in one peice, above that depth the bulb half is rolled separately from the upper or T half and the two are welded together along the neutral axis of the beam.

Preparations of Beams.

While the frames and keel of the ship are in progress, beam moulds, with the spring and length marked on them, are given out to the workmen to guide them in making the beams. The processes of bending and straightening the beams are performed by means of screw presses worked by hand or hydraulic presses, the beams being cold. In forming the beam knees the ends are the only parts put into the fire, and the plan adopted in nearly all instances is to split the beam arm for a short distance, turn the lower part down and weld a peice of plate iron in. The moulding of the frames determines the number of rows of rivets which may be employed in connecting the beam knee with the frame, double or treble zigzag riveting being preferred for this porpose. In setting off the fastenings in the knees *templates* are used. These templates are put in place at the ship, and the holes are arranged so that they may clear the holes in the other flanges of the frame angle-irons, two rivets being usually put in the upper part of the beam arm above the line of the welde made in forming the knee. The templates are then removed to the beams and the positions of the holes are transferred to the knees. After the holes have been drilled or punched in the knees, the beams are put in place, set fair to the beam line, and fixed, and then the holes are drilled through the frames.

PROCESS OF FRAMING.

When the keel has been fixed in position on the permanent blocks, the process of framing is commenced, the frames amidships being first put up, and the work being continued forward and aft simultaneously. Before any frames are raised, staging is erected at the topsides, and the sheer or gunwale harpins are suspended from it, ready to receive the frames when raised in place. When raised, the frames are shored, stiffened by cross-spalls, and temporarily secured at the keel; when a considerable number has been put up the other harpins and ribbands are fixed in place and the frames regulated. Stages are then made around the ship (without being secured to *any part* of her) at different heights for the purpose of proceeding with the plating, the latter operation being commenced as soon as the frames are regulated and secured in place.

Preparations of Floor Plates and Reversed Angle Irons.

In the meantime the floor plates are prepared from the lines got in on the blackboard, and having been bent to form, are put in place, and have the holes for the fastenings to the frame angle irons marked. They are then taken out of the ship, the holes in the upper edge for the reversed bars are set off, and all the holes are punched. The floors are then fixed in place and temporarily secured with bolts and nuts. The reversed bars are also prepared while these operations are proceeding, and are bent, bevilled, punched and faired in a similar manner to the frame angle-irons. In taking account of the holes secureing the reversed angle-iron to the frame and floor plate, it is usual to use a light batten, which is bent around the line of the holes after the frame and floor plate are fixed in place, and then transferred to the reversed bar. When the preparation of the reversed angle-irons is completed they are put in place, and the riveting up of both the floors and reversed bars to the frames proceeds simulataneously. Before getting the beams in, it is usual to work a stake of plating at or near the beam ends, and to shore the ship at this part. The whole of the work connected with the construction of the vessel is thus progressing simultaneously. When the ship is properly regulated, the spots notched on the frames at the plate edges, heights of decks, &c., are faired through and corrected by means of battens, and the lines are then marked in on the frames.

Description of Ordinary Mode of Plating a Ship.

In plating a ship, the inside ~~stakes~~ are first worked, and the position and *shift of butts* are made to correspond with the arrangement previously made on the model, the foreman in charge of the work usually having a duplicate of the model to

guide him in regulating the plating. According to the plan now in general use, each alternate stake is worked directly on the frames, and the intermediate stakes form an outer layer, each stake of which overlaps the edges of the two adjoining stakes of the inner layer. The stakes worked on the frames are termed *sunken* or *inside stakes*, and those of the outer layer *raised* or *outside stakes*. The lowest stake of the outside plating is generally an inside stake, and is, in most cases the first stake put on, the work being continued upwards and the two inside stakes upon which an outside stake laps being fixed in place before it is worked. As soon as the inside stakes are riveted to the frames, the harpins which were originally placed in wake of the outside stakes are removed, and the ship is shored under the inside stakes, thus leaving the space free for working the outside stakes.

In taking account of the bottomplating, templates are generally used, the most common form of template consisting of a light batten mould of which the outside dimensions are a little greater than those of the plates. Cross battens are fixed on the templates at intervals corresponding to the frame space, and when the templates are put in place at the ship these battens cover the frames. For a plate of an inside stake it is only necessary to take account of the edges and butts on the battens forming the frame of the template, and of the positions of the rivet-holes in the frame angle-irons on the cross-battens. The positions of the holes are marked upon the template by means of a wood plug with a hollow end, or a hollow cylinder, which is dipped in white lead, and put through the holes from the inside, thus marking the outlines. When the account has been taken the template is taken down and laid on the plate, and the positions of the lines and the rivet-holes are transferred to it. The method of transferring the position of the holes requires some notice, as in many cases bad work is caused by carelessness in this respect; full particulars of the operation will be given further on. The edges of the plates are next sheared, and the butts planed to the lines obtained from the template, after which the position of the rivets in the edges and butts are set off. In setting off the edge riveting of inside stakes, templates are used which have the positions of the holes marked upon them. As the frame space and the pitch of the rivets in the edges are constant quantities, this mode of setting off the fastenings is a very good one, the only care required being to make the edge fastenings work in well with the butt fastenings with the adjacent stakes. This can be readily done if two templates are employed, the first having the edge fastenings arranged to suit the frame spaces in which a butt comes, and the second being adapted to frame spaces in which there is no butt of the adjacent stakes.

Templates are also used for setting off the butt fastenings.— The centres of the holes are generally bored through the templates and in order to transfer the positions to the plates a sharp pointed centre punch is driven through the template. After the holes have been punched the plate is curved by passing it through the rolls, the proper curvature being secured by the use of section moulds made to the frames nearest the butts, the backs of the moulds being out of winding. In some portions of a ship's bottom the amount of curvature is so small as to render this operation unnecessary; but in other portions special care is required as will be explained more fully hereafter. When the sheet has been sheared, planed, punched and curved as above described, it is put in place and temporarily secured by bolts and nuts.

In working a plate of an outside strake a similar template is used, and when put in place, in addition to having the positions of the butts and edges of the plate, and rivet-holes in the frames marked upon it, account has to be taken of the rivet-holes in the edges of the inside plates which it overlaps. In making the positions of the holes upon the template the same method is adopted as is described above for the plates of an inside strake. When the holes have been marked the template is removed and laid on the inside of the plate, and the holes are then transferred from the inside of the template to the outside of the plate. This is done by means of a "*marker* or *reverser*" of the form shown in the figure. The end of the marker is forked, in order that it may be put over the edge of the template *t*, and have the hole *a* in the upper part brought exactly over the outline of the hole marked on the template. On the lower limb of the marker there is a projecting plug *b* vertically under the hole *a*, and as the template *t* is checked up at such a height above the plate *p* as to allow the lower part of the plug to just clear the surface of the plate when the hole *a* is brought well with the outlines marked on the template.— When the marker has been placed in this position the workmen presses down the plug *b* on the plate, and as the plug has been previously dipped in white lead it marks the position of the hole to be punched. Both the hole and the plug on the marker are of the same diameter as the rivets used. The plates of the outside strakes are punched from the inside on account of the fact that it is the faying surface: but the holes for the edge riveting in the inside strake require, for a similar reason, to be punched from the outside, while the holes for the rivets securing all plates to the frames, and those for the butt fastenings, should always be punched from the inside. The remaining operations involved in the preparation of a plate of an outside strake,— punching, shearing, planing, &c.,— are identical with those described above for an inside strake,

and when they have been completed, the plate is temporarily secured in place with bolts and nuts. The pieces filling up the space between the frames and outside strakes, called *liners*, are fitted after the plates are prepared and fixed. Wooden templates are used in preparing the liners, being put in place in order to have the position of the rivet-holes marked, and then transferred to the liners. The holes are punched in the liners. When the curvature of the frame is at all considerable the liners are bent to the form required. After their preparation is completed the liners are driven in between the plates and angle-irons by the workmen, and fixed in their proper position. With comparatively light plates, the wooden templates are often dispensed with, and the plates themselves are put up and marked, but the ordinary practice is that given above, in order to receive the edge fastenings of the adjacent plates. The liners to the outside strakes are of the breadth of the frame angle-irons, on all except the bulkhead frames where they extend to the adjacent formes before and abaft.

Mode of Working Deck Stringers.

While the plating is being proceeded with, the work in the interior of the ship is also advancing, the riveting of the reversed angle-irons and floor plates being completed, the beams being got in and fastened, the deck and hold stringers being fitted and fastened, &c.

The usual mode of fitting deck stringers consists in laying the plate upon the beams and taking account upon it of the curve of the edge, position of scores, rivet holes, &c. In the greater number of iron ships, the only partial iron deck which is fitted is composed of *stringer-plates* and of fore and aft and diagonal *tie-plates*. These are of service in adding strength and preventing change in the longitudinal form of the ship. Stringer-plates and angle-irons on the beam ends, act as horizontal knees to the beams, and their efficiency is increased by working upon the stringer-plates continuous angle-irons, which serve both as stiffners to the stringers and as gutter waterways at the side. The tie-plates usually worked on the various tiers of beams, are arranged so as to have two placed longitudinally, one on each side of the hatchways, and the remainder placed diagonally and running from side to side between the hatchways. These plates serve to prevent the racking forces which are brought into play when the ship is heeled over, or lies across a series of waves. These plates are well riveted to the beams which they cross.

Method of Taking the Shape for and Working Plates with Large Amounts of Curvature and Twist.

In cases where a plate has a large amount of twist, special means are employed to ensure accuracy in taking account of it.

The common plan is to take four iron rods about $\frac{3}{8}$ inch diameter, to cut them to the lengths of the edges and butts of the plates and to weld them at the corners. The frame thus formed is put up in place at the ship, and bent to the shape required to give a correct account for the plate. Short pieces of angle-iron are then bent to the curve of the frames, and a bed is formed which has these angle-irons for its transverse framing, their ends being placed well with the twist given by the iron frame. The plate is heated and bent to the form of the bed, after which it is put up in place and fitted, the holes being drilled. All difficult twisted plates with considerable curvature are thus worked, and the iron in the plates requires to be of a superior quality in order to stand the bending. The various processes of marking, bending, punching, &c., are performed by workmen known as "*platers*," each being assisted by from 4 to 6 helpers, the number of the latter being regulated by the weight of the plates, averaging about one man to every cwt.

Ordinary Arrangement of Riveting in Outside Plating.

The edges and butts of bottom plating are generally double-chain riveted, but in some cases treble-chain riveting is employed for butt fastenings. The pitch of the rivets in the edges is from $3\frac{1}{2}$ to 4 diameters. It is usual to *joggle* the butt straps to the outside plates. As the weight of the stringer plates is not usually very great, and they are easily moved and placed, this is found to be the best mode of procedure, no moulds being required to be made.

Deck Planking for Iron Vessels.

The employment of wood planking for the decks of iron vessels is almost universal, even when iron decks are laid on the beams. In most cases each plank is secured by a bolt in each beam-flange. The different modes of fastening that have been adopted are illustrated on the blackboard before you.—The first, consists of a wood screw hove up from beneath and passing into the plank for about three-fourths of its thickness; the second, is formed by a screw-bolt driven down from above, and secured by a nut hove up underneath the flange or iron deck; the third, consists of a screw-bolt hove up from beneath and secured by a nut let down into the plank; and the fourth, is formed by combining the first two fastenings, care being taken that the wood screws on adjacent beams shall fasten opposite edges of a plank. The second plan is that most usually adopted.

PREPARATION OF BULKHEADS.

Watertight bulkheads in iron vessels, are always placed transversely, but there are, in many instances longitudinal

watertight divisions also. In many steamships the longitudinal bulkheads enclosing the coal bunkers are made watertight, and thus form subdivisions in the compartments bounded by the transverse bulkheads. In the armour-clad frigates of the English Navy, the wing-passage bulkheads form longitudinal divisions of the hold, while advantage is taken of the subdivisions formed by the bulkheads of magazines, shell rooms, chain lockers, shaft passages and passages between engines and boilers, all of which are made watertight. The putting up of the transverse bulkheads is delayed as long as is consistent with the progress of the work, in order to allow free access to every part of the hold. The plates, butt straps, &c., of the various bulkheads are prepared, fitted and punched outside the ship, in readiness for being put together, and when the work is sufficently advanced they are put in place and riveted.

Putting in and Testing Rivet Work.

After working about three-fourths of the outside plating of the ship, men are set to work at closing up the joints, riming out unfair holes, &c., preparatory to the riveting being commenced. The riveting is generally done by piece-work, a set of riveters being composed of two riveters, a holder up, and two boys to heat and carry the rivets. The rivets used in the outside plating are of a conical form under the head, and the heads of all the rivets in the ship are laid up. Care is taken that the holes are well filled, and the points of the rivets flush with the surface of the plates. In order to try if the surfaces of the plates are brought close, and to test the tightness of the rivets, the following course is adopted: Rivets are marked in different parts of the ship, and the rivet on each side of a marked rivet is cut out. Screw-bolts of the size of the rivet are then placed in the holes and hove up as tightly as possible, in order to try if the rivet between them can be loosened, which will only be the case if the work was not properly drawn together when the rivets were put in.

CAULKING LAPS AND BUTTS OF PLATING.

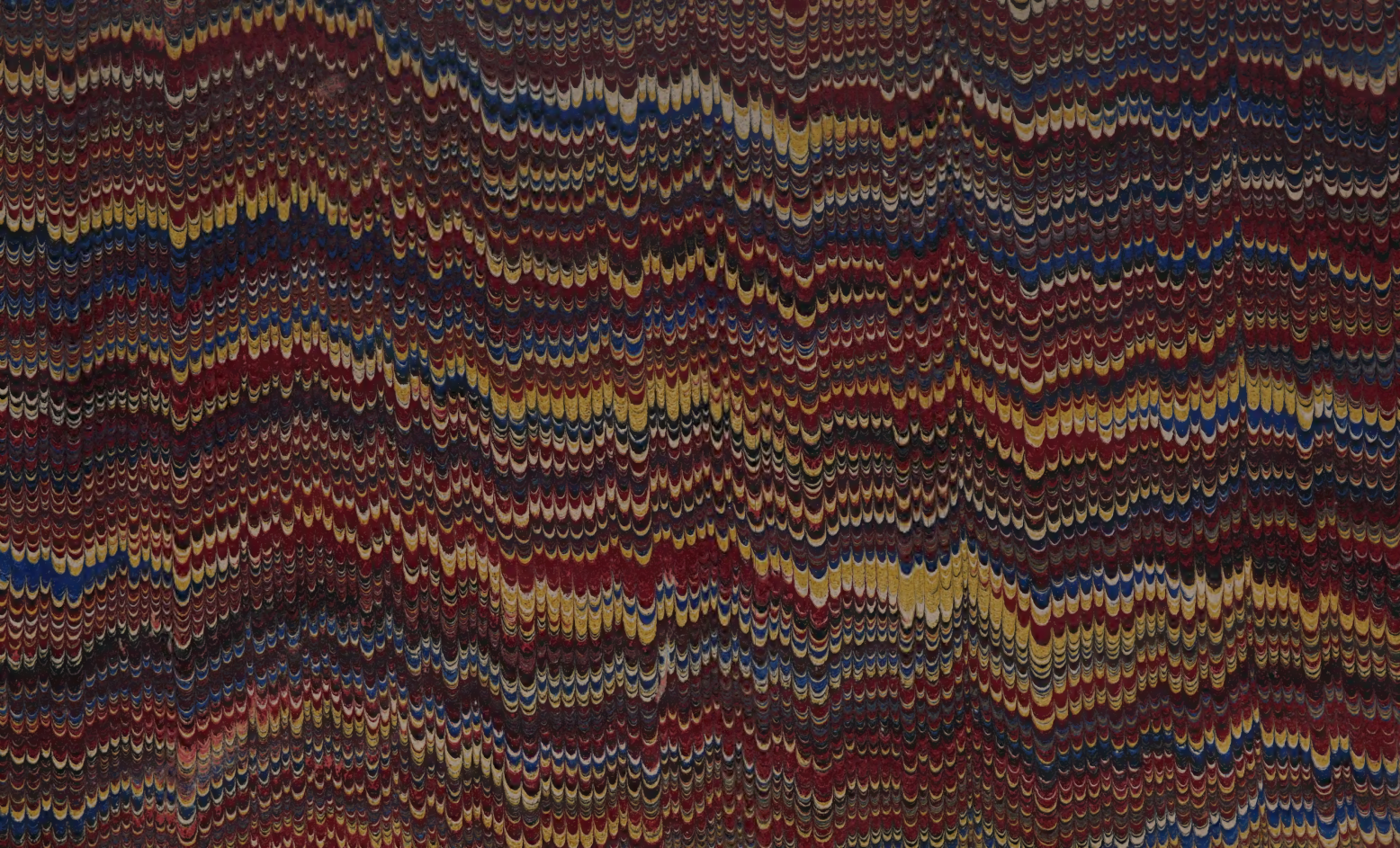
When the riveting has been advanced to some extent, the edges (when not planed,) are chipped fair and cleaned, and then the caulking of the butts and edges is commenced. In caulking a lap-joint the edge of the plate is first fullered with a tool, then it is split with another tool, and lastly the splitting tool is reversed, and the split part of the edge is driven against the plate which it overlaps, as shown in the figure on the blackboard.

The caulking of a butt-joint differs from that of a lap-joint in requiring the butts to be first clipped smooth, then split on both sides of the butts and afterward fullered off, as shown in

the figure on the blackboard. The closeness of the joints its tested before they are caulked by trying to insert a thin steel blade at various parts.

The caulking being found satisfactory, a painter follows, and thus marks the work complete, while oxidation of the finished portion is prevented.

Three coats of red lead paint is put upon the bottom before launching.



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